REPORT RPT-001-005

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MARINE SEISMIC SYSTEM DEPLOYMENT (MSS) PHASE II

Investigation of techniques and deployment scenarios for installation of triaxial seismometer in a borehole in the deep ocean.

AD A095678

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09 JANUARY 1981

FINAL REPORT FOR PERIOD 10 *JUNE* 1980 - 30 SEPTEMBER 1980

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(12) 485

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 001-005	2. GOVT ACCESSION NO.: AD-A095678
3. RECIPIENT'S CATALOG NUMBER: (9)	
4. TITLE (and Subtitle): (6) Marine Seismic System Deployment (MSS), Phase II. Investigation of Techniques and Deployment scenarios for installation of triaxial seismometer in a borehole in the deep ocean.	5. TYPE OF REPORT & PERIOD COVERED: Final rept. 10 June-30 Sept 1980
	6. PERFORMING ORG. REPORT NUMBER: (14) RPT-001-005
7. AUTHOR(s): R. D. + L. Wallerstedt	8. CONTRACT OR GRANT NUMBER(s): (15) N00014-80-C-0821, ARPA Order-3693
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Global Marine Development Inc. 2302 Martin Street Irvine, CA 92715	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: ARPA Order 3693
11. CONTROLLING OFFICE NAME AND ADDRESS: Defense Advanced Research Projects Agency (DOD) ARPA Order 3693	12. REPORT DATE: 30 Nov 1980
	13. NUMBER OF PAGES: Approx 300
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Naval Ocean Research and Development Activity NSTL, Bay St. Louis, Mississippi (11) 9 Jan 81	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

[redacted]

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Marine Seismic System
Deep Ocean Seismic Instrumentation Deployment
Borehole Instrumentation Package

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of the Phase II detail design and planning effort oriented primarily toward the initial Marine Seismic System (MSS) At-Sea-Test scheduled for March 1981. The At-Sea-Test operations will be conducted using the Deep Sea Drilling Project (DSDP) drillship GLOMAR CHALLENGER for an estimated period of six days.
The overall MSS deployment program plan and associated costs est. has been upgraded to reflect the emplacement of two boreholes, and the deployment of one configuration I BIP system in the North Pacific during the period of June-July 82.

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Reference: (a) MIL-STD-847A of 31 January 1973

Enclosure: (1) RPT-001-005, "Final Report For Period 10 June 1980 - 30 September 1980," dated 9 January 1981

Dear Mr. Ballard:

On 30 September 1980 a draft of the final report was submitted to NORDA for review. Enclosure (1) reflects the initial release of the final Phase II report which incorporates NORDA comments and clarifies certain aspects of the presentation, particularly the Appendicies.

The final report is submitted in accordance with the requirements of the subject NORDA contract and Reference (a).

We have been pleased to participate in the Phase II portion of the overall MSS Program and look forward with anticipation to a successful demonstration and a continuing association.

Sincerely,

J. A. Farkas
Contract Administrator

JAF:lw

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A	9/30/80	R. WALLERSTEDT	PRELIMINARY DRAFT	ALL
0	01/09/81	R. WALLERSTEDT	INITIAL RELEASE	EXECUTIVE SUMMARY 3-5, 3-6, 3-7, 3-8 4-1, 5-2, 5-3, 6-4 6-6, 7-2, 7-3, 8-4, 10-8, APPENDIX A,B, C, E, H-2 DELETED H-3 DELETED I, J

EXECUTIVE SUMMARY

This report presents the results of the Phase II detail design and planning effort oriented toward the initial Marine Seismic System (MSS) At-Sea-Test which is presently scheduled for March 1981. The At-Sea-Test operations will be conducted using the Deep Sea Drilling Project (DSDP) drillship GLOMAR CHALLENGER for an estimated period of six days. The design for the test Borehole Instrumentation Package (BIP) reentry-sub and associated handling equipment has been completed and has been submitted for vendor bid. Details of the specialized support equipment for installation on the GLOMAR CHALLENGER are presently being coordinated with the DSDP Project Office (Scripps Institution of Oceanography) and Global Marine Drilling Co. (GMDC), the operators of the ship. A preliminary At-Sea-Test mobilization plan has been generated, along with the test plan, interface requirements specification and integrated activity schedule. An At-Sea-Test design and operational scenario which will meet the defined test requirements and which will demonstrate the baseline BIP deployment concept have been developed. The overall very tight fabrication, test and delivery schedule is of primary concern.

Cable entanglement is a problem of major concern. Analysis indicates that there is a low probability of self-locking entanglement of the EM Cable around the drill string as long as adequate tension is maintained in the cable. However, because of technical and operational uncertainties, the possibility of entanglement persists. Accordingly, a procedure to safely disentangle the cable has been prepared. In addition, a back-up plan, using a tethered fairleader run from the Navy support vessel, is being developed as a positive means of preventing overlap, or wrapping, of the cable around the drill string when exposed to adverse current conditions.

The evaluation of alternate reentry concepts, which would not require the use of a dynamically positioned drillship, strongly indicated that a tethered fly-in approach was preferable to a single or dual guideline system. Existing technology and equipment are available to confidently initiate planning activities for such a deployment. Selection of the most optimum and

cost-effective fly-in-platform configuration can be made once specific Configuration II operational requirements are defined.

Early planning for the June - July 1982 Configuration I deployment has been initiated. No major problems are foreseen in using the At-Sea-Test design to extrapolate to the more difficult and deeper North Pacific deployment site. Two boreholes will be emplaced and a prototype BIP will be deployed in one of these holes.

The Configuration I system and its associated requirements, remain to be finalized. This must be done as early as possible so that mobilization planning can be efficiently conducted. This will be a rather complex operation involving 40 or more days of at-sea operations and possibly two or three support vessels. Some of the major mobilization activities are to be accomplished in a foreign country, with the most probable location being Japan.

The overall MSS deployment program costs through September 1982, have been estimated at approximately $4,327,000. The March 1981 estimate for the At-Sea-Test portion of the program is $1,093,670.

GMDI recommends that the preliminary design of the Configuration II fly-in platform's reentry system be initiated by mid-1981 as soon after the At-Sea-Test as possible. However, definitive Configuration II criteria and requirements must be first defined so that a technical and cost-effective reentry platform configuration can be selected. The overall system design must be completed in 1982 in order to meet the June - July 1983 schedule.

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SECTION 1.0 - INTRODUCTION

The Marine Seismic System (MSS) is a DARPA sponsored program to develop reentry and deployment equipment which is capable of installing a seismic Borehole Instrumentation Package (BIP) and its associated support equipment into the ocean bottom basalt layer in water depths up to 6,096 meters (20,000 feet). A deep borehole will be drilled and cased through the sediment into the basalt layer, utilizing standard deep ocean drilling techniques developed under the direction of the Deep Sea Drilling Project (DSDP) by the dynamically positioned drilling vessel GLOMAR CHALLENGER. Deployment of the BIP into the borehole will be accomplished utilizing a procedure wherein a reentry sub is lowered to the bottom with the drill string and stabbed into the borehole reentry cone. This reentry sub incorporates a reentry tool which is used to guide the BIP into the borehole. The proposed BIP reentry concept modifies specific operational procedures, developed by the DSDP team, which have been repeatedly demonstrated over more than seven years of GLOMAR CHALLENGER operations.

The overall MSS Program consists of three major operational elements:

1. At-Sea-Test Reentry Demonstration in March 1981
2. Configuration I Deployment in June-July 1982
3. Configuration II Deployment in June-July 1983

In July of 1980, a presentation was made to the JOIDES Planning Committee proposing the use of the DSDP GLOMAR CHALLENGER for the MSS Program. Based upon this presentation and subsequent meetings, a provisional agreement was negotiated between DARPA and National Science Foundation (NSF) in September of 1980. The following planning has subsequently been coordinated with DSDP:

- A six-day At-Sea-Test demonstration of the BIP reentry capability will utilize the GLOMAR CHALLENGER to reenter an existing DSDP borehole located in the Mid-Atlantic.
- Two boreholes will be drilled in the North Pacific during the period June-July 1982 using the GLOMAR CHALLENGER.
- A prototype MSS (designated Configuration I) will be deployed in one borehole during this same 1982 time frame.

- o A second MSS (Configuration II) deployment into the second hole is scheduled for the following year in the period June-July 1983. Since the GLOMAR CHALLENGER may not be available for this latter demonstration a different ship and reentry/deployment concept will be considered as an alternate.

Under contracts for the U.S. Navy and DARPA, the installation and operation of a special deep ocean seismic instrumentation package has been studied by several contractors over the past year. GMDI was contracted to conduct the initial Phase I portion of the MSS Deployment Feasibility Study (see Reference 1). This initial effort was completed in June of 1980. A follow-on Phase II At-Sea-Test Design and Mobilization Planning Program contract (see Reference 2) was also issued to GMDI. This Phase II portion of the study was completed in September of this year. Subsequent phases of planned work are:

Phase III Oct 1980 - Sept 1981, "Shore and At-Sea Testing"
Phase IV Oct 1981 - Sept 1982, "Configuration I Mobilization and Operations"
Phase V Oct 1982 - Sept 1983, "Configuration II Mobilization and Operations"

The overall MSS Deployment Program has been separated into a series of successive fiscal contract phases. *Figure 1-1 depicts* the relationship of the fiscal phased work efforts with the major operational programmatic elements.

MARINE SEISMIC SYSTEM PROGRAM SCHEDULE

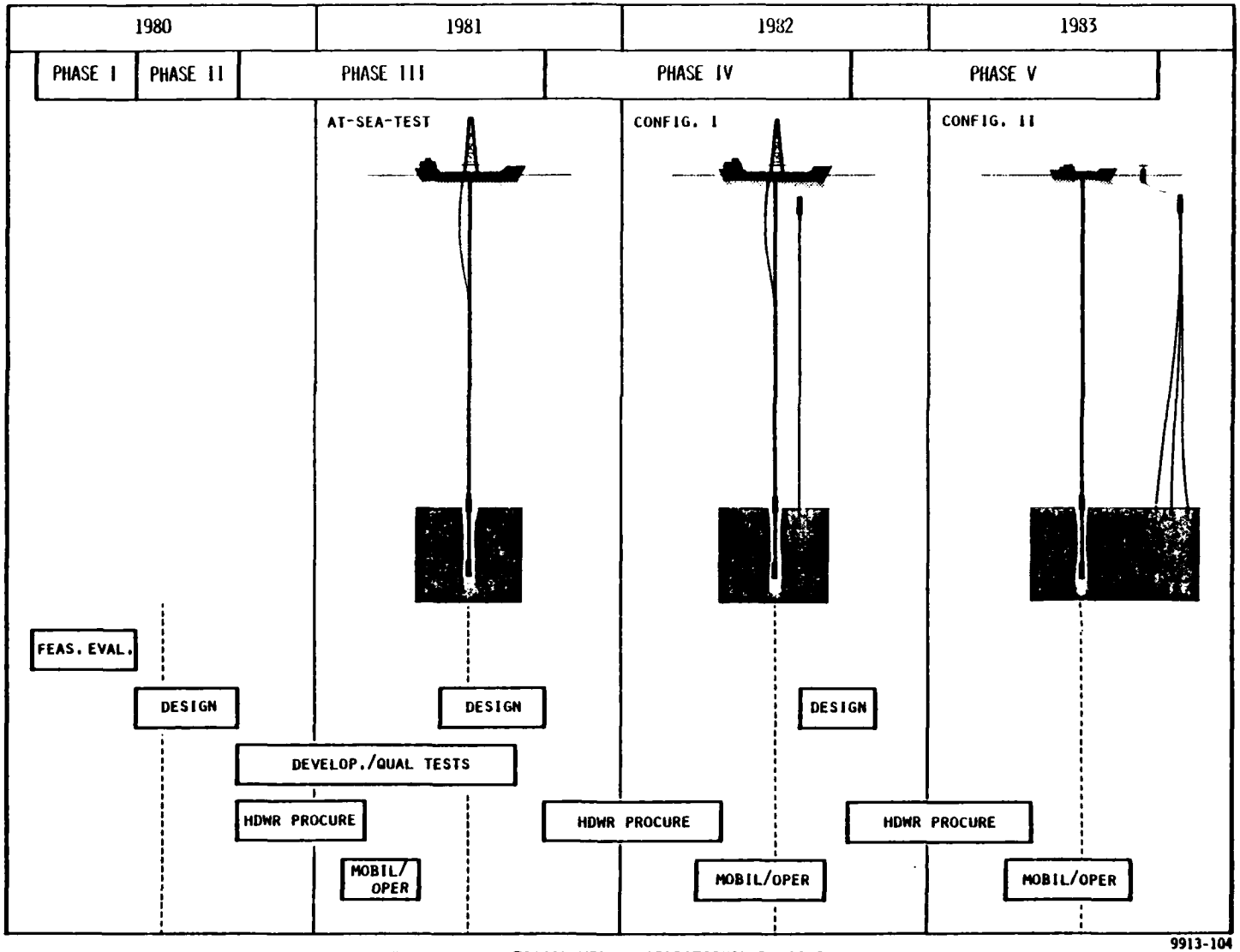


FIGURE 1-1. FISCAL VERSUS OPERATIONAL PHASING

SECTION 2.0 - CONCLUSIONS AND RECOMMENDATIONS

An At-Sea-Test design and operational scenario has been accomplished that will meet the defined requirements necessary to demonstrate the baseline BIP deployment concept. The major reentry sub equipment is out for vendor procurement and details of the handling equipment and their shipboard installation are being finalized. An At-Sea-Test plan interface requirements specification, and integrated activity schedule have been issued and are updated periodically. A preliminary mobilization plan has also been issued to coordinate the overall program. The overall very tight fabrication, test and delivery schedule is of primary concern.

The major concern of cable entanglement has not been resolved. The analysis indicates that there can only be a low probability of self-locking entanglement of the EM Cable around the drill string as long as adequate tension is maintained. However, because of the technical and operational uncertainties, a risk of possible entanglement persists. Accordingly, a procedure to safely disentangle the cable is being prepared. In addition, a back-up plan to use a tethered running fairleader off the Navy support vessel is being developed as a positive means to prevent overlap or wrapping under adverse current conditions.

The evaluation of alternate reentry concepts, not requiring the use of a dynamically positioned drillship, strongly indicates that a tethered fly-in approach is preferable to a single or dual guideline system. Existing technology and equipment are available to confidently initiate planning for such a deployment. Selection of the most optimum and cost-effective fly-in-platform configuration can be made once specific Configuration II operational requirements are defined.

Early planning for the June - July 1982 Configuration I deployment has been initiated. No major problems are foreseen extrapolating from the At-Sea-Test design to the more difficult and deeper North Pacific deployment site.

The Configuration I system and its associated requirements need to be finalized at an early time in order that thorough mobilization planning can be achieved. This will be a rather complex operation involving 40 days or

greater of at-sea operations involving possibly two or three vessels. Some of the major mobilization activities must be accomplished in a foreign country, probably Japan.

It is recommended that the preliminary design of the Configuration II fly-in platform's reentry system be initiated in mid-1981 right after the At-Sea-Test. Definitive Configuration II criteria and requirements must be first defined in order that a technical and cost-effective reentry platform configuration can be selected. The overall system design must be finalized during 1982 in order to meet the June - July 1983 schedule.

This Phase II report represents the MSS At-Sea-Test program as of the end of October 1980. There has been subsequent minor changes in detail design, specific operational procedures and overall program schedule.

SECTION 3.0 - AT-SEA-TEST BASELINE DESIGN

3.1 ABSTRACT

A sequence of scenarios for the At-Sea-Test was developed. The scenarios form the basic building block for development of detailed procedures during the Phase III effort. Preliminary equipment arrangements onboard the GLOMAR CHALLENGER were prepared preparatory for review with DSDP. Detailed fabrication drawings for the BIP Reentry Sub were developed along with a thorough analysis of the impact forces during reentry.

3.2 OBJECTIVES

The objectives of the design for the At-Sea-Test were:

- To develop scenarios and hardware design for deploying a BIP in an existing borehole. The borehole to be used is at site 395A which was drilled by the GLOMAR CHALLENGER in January 1976. This site is located east of the Mid-Atlantic ridge in 4,485 meters (14,715 feet) water depth.
- The procedures and hardware design should be state of the art and similar to those normally used by the GLOMAR CHALLENGER.
- The test plan outline for the At-Sea-Test is defined in Appendix A.

3.3 DESIGN REQUIREMENTS

- BIP to be deployed is 8.7 meters (28-1/2 feet) long x 203 millimeters (8 inches) OD and weighs 1,497 kilograms (3,300 lbs) as shown on Geotech Dwg 990-53100 (Interface Control).
- BIP reentry sub is to be designed so as to limit the shock loading on the BIP during reentry to maximum of 10Gs.
- Loads on drilling string are to be no more than those normally experienced during drilling operations.
- BIP is to be placed in the borehole and data recorded for period of 24 hours.

- o Detail requirements are defined in the At-Sea-Test Interface Requirements Specifications shown in Appendix B.

3.4 ASSUMPTIONS

- o Maximum velocity of reentry is 3 meters/sec. (10 ft/sec.).
- o EM Cable is to be torque balanced coaxial (0.692 inch) diameter with breaking strength of 9,100 kilograms (21,000 lbs). Cable characteristics have been defined in the Appendix B specification.
- o Impact loads during reentry are measured by two 3-axial accelerometers in the BIP and recorded at surface.

3.5 SUMMARY OF RESULTS

The scenarios for the deployment and retrieval of BIP during the test are shown in Section 4.0. The total time for the test is estimated to take about 4-1/2 days. This does not allow for any contingencies due to down time for major equipment failure or bad weather. The major risk in the deployment is the possibility of cable entanglement. However, this risk can be reduced by obtaining current data and maintaining proper EM Cable tension. Plans to undo cable entanglement, should it occur, and a back-up method to provide greater assurance against entanglement are being developed.

Detailed fabrication drawings of the BIP reentry subs and special tools required for deployment of the BIP were prepared. Subsea interface control drawings have also been developed. These drawings are included in Appendix J.

Impact analysis on the BIP reentry sub and BIP (without shock mounts) during reentry showed the maximum shock loading on the BIP to range from 7Gs to 12.4Gs (refer to Appendix E). With proper shock mounts this is reduced to less than 5Gs.

The maximum dynamic stress at the striking end of the BIP reentry sub is 490 kPa (71 ksi) during impact (refer to Appendix E).

The EM Cable Winch and the instrumentation van shall be located under the casing rack on the main deck. An "A-Frame" shall be provided on

the portside for paying out the EM Cable. Twelve kw of 440/220V, 60 Hz ships power will be furnished to the instrumentation van.

3.6 TECHNICAL DISCUSSION

The location of the At-Sea-Test is site 395A which was drilled in January 1976 by the GLOMAR CHALLENGER. The site is located approximately 2,172 kilometers (1,350 miles) east of San Juan and west of the Mid-Atlantic ridge at $23^{\circ}N$ x $46^{\circ}W$ in 4,485 meters (14,715 feet) water depth. Figure 3-1 shows the characteristics of the borehole at site 395A. Even though the total depth drilled was 664 meters (2,178 feet) the hole was abandoned due to extreme torque problems as a result of caving at the bottom of hole and trapping of cuttings. The hole was left with mud pack and without any logging data.

During the March 1981 tests it is anticipated that the borehole would first be cleaned out and logged to satisfy the scientific objectives. Subsequent to the scientific tests, the MSS tests shall begin with the setting of a cement plug* about 12 meters (40 feet) below the 298 millimeters (11-3/4 in.) casing. The cement plug would provide a firm foundation for placement of the BIP so as to gather seismic data. The scenarios for the MSS tests are shown in Figures 4-1 through 4-14. The scenarios are generalized at this stage. However, in Phase III GMDI shall develop the detailed procedures. The scenarios illustrate the approximate time for each major operation. The actual time for the MSS test, including 24 hours of data recording, is estimated to be 4-1/2 days. This time does not allow for any major equipment breakdown or down-time due to bad weather.

One of the major areas of concern during the test is the risk of cable entanglement with the drill pipe. Since the source of entanglement is basically the currents and cross currents, it is essential to know the current profiles so that the vessel could be headed in an optimum bearing for station keeping and reducing risk of cable entanglement. Another major factor to reduce cable entanglement is maintaining proper tension on the EM Cable. Refer to Section 8.0 for a more detailed assessment of this problem.

*The cement plug has been recently deleted.

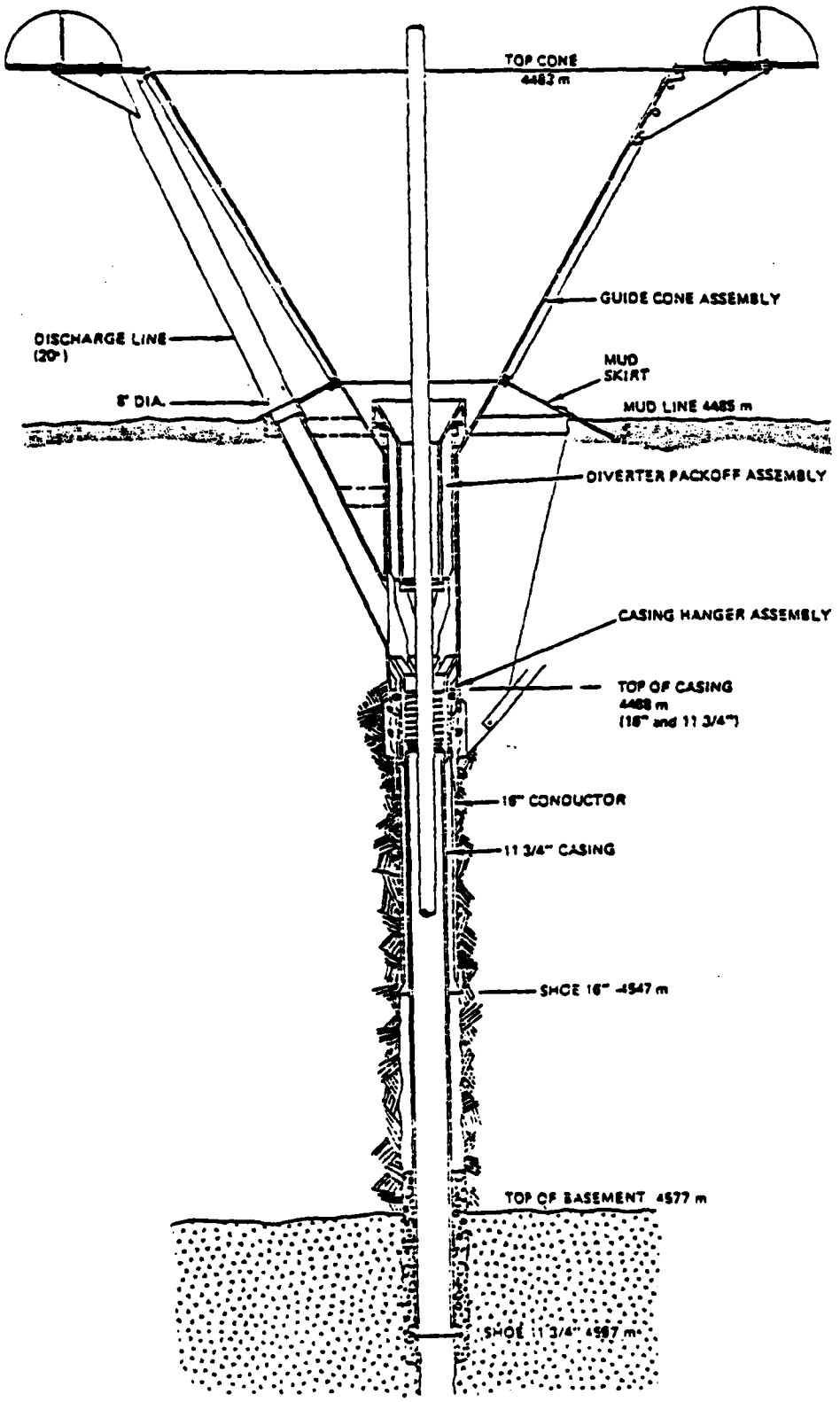


FIGURE 3-1. SCHEMATIC OF REENTRY CONE AND CASING AT MUD-LINE HOLE 395A.

GMDI drawing E-001-A002 shows the overall reentry assembly. The total length of the assembly is about 97 meters (320 feet) and weighs about 20,865 kilograms (46,000 pounds) which is very close to the normal bottom hole assembly used on the GLOMAR CHALLENGER during drilling operations.

The overall arrangement of the BIP reentry sub and the position of the BIP during deployment is shown in Figure 3-2. Further details can be found in drawing E-001-A001. The BIP is enclosed in a carriage and set in a side pocket inside the reentry sub. Once the reentry has been made into the cone, the BIP is centered and released by actuation of salt water hydraulic cylinders pressurized from the surface. Details of the BIP carriage are shown in drawing D-001-A004. To reduce the shock loading on the BIP during reentry, the BIP is shock mounted with rubber pads as shown in drawing C-001-A006 and E-001-A005.

Drawing E-001-A009 shows the assembly of BIP reentry sub, stinger, and BIP centering and release hydraulic mechanism. Details of the reentry sub are shown in drawings E-001-A008 and E-001-A005. A 38.1 millimeter (1-1/2 inch) slot is provided in the BIP carriage, reentry sub and also the stinger. This slot allows the cable to fall out of the bottom assembly once the BIP is lowered. In order to prevent the cable from being damaged in the borehole, a gate has been provided to keep the cable centered within the reentry sub until it is raised clear of the cone. The gate is then opened by salt water hydraulic pressure from the surface to allow the cable to fall out of the slot.

Drawing D-001-A007 shows the details of the reentry stinger. The bottom end of the stinger is made of high strength steel to avoid damage during reentry. Rubber strips have been provided on the outside of the stinger to centralize it in the casing and avoid the possibility of the cable being damaged.

Drawing D-001-A010 shows details of a special hydraulic plug/sonar adaptor. This plug fits inside the bottom end of the reentry stinger to provide a shelf for seating of the sonar reentry tool. Once the reentry operation has been conducted this plug will be raised up

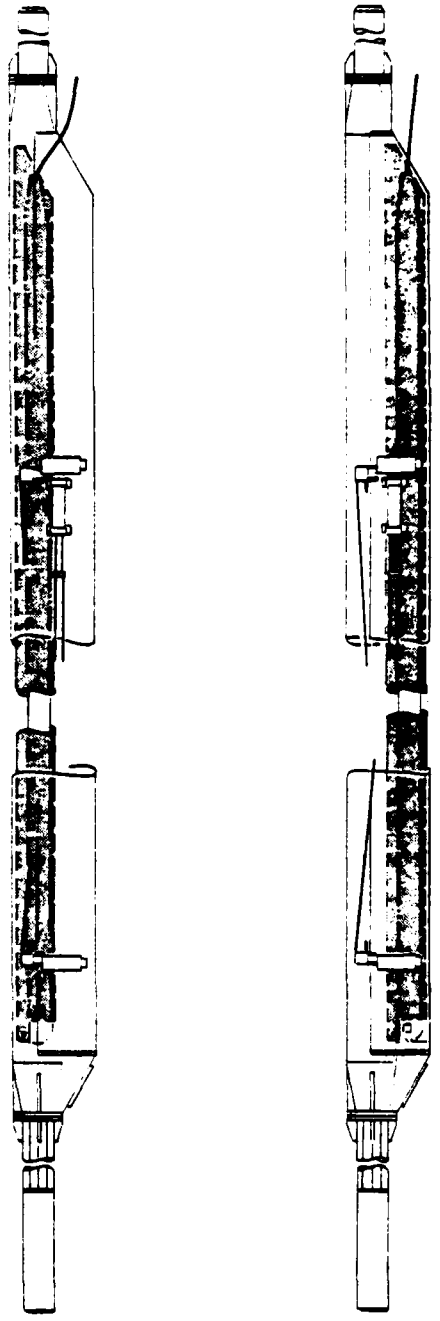


FIGURE 3-2. SCHEMATIC OF MSS BIP AND REENTRY SUB

0006-005

above the BIP and secured inside the BIP carriage control sub. Details of this sub are shown in drawing E-001-A003. Prior to actuation of the BIP releasing hydraulic mechanism a special Baker plug is sent down on wire line. A fishing tool is used to latch into the hydraulic plug/sonar adaptor unit and raise it into the control sub. The Baker plug then seals the reentry sub from the drill pipe thus allowing actuation of hydraulic cylinders by water pressure from surface through the drill pipe.

A thorough analysis of the impact during reentry was conducted. This analysis is included in Appendix E. The analysis shows that the maximum acceleration in the BIP area without shock mounts is in the range of 7Gs to 12.4Gs. Use of shock mounts reduces this to less than 5Gs. The shock loading on the bottom end reentry stringer is 24Gs with an associated impulse impact loading of 14,390 kilograms (164 kips). The maximum impulse stress in the striking end of the stinger is 490 kPa (71 ksi) and 214 kPa (31 ksi) in the drill collar portion of the assembly.

Figure 3-3 (Ref: Dwg E-001-A028) shows the location of major MSS test hardware on the vessel. Both the EM Cable winch and the instrumentation van are located below the casing rack. An over the side "A-Frame" is located on the port side within reach of the 50 ton crane. Detail design of the "A-Frame" is shown in Drawings A022 through A024.

Details of the associated heave compensation and cable protection equipment E-001-A013, A014, A018, A020, A030 and P001. The total power requirement for instrumentation of the van is 12 kw, 440/220V AC, 60 Hz, 3-phase. This power is to be supplied from the ships power. The specific installation is being coordinated with DSDP Project Office and GMDC.

3.7 SONAR REENTRY TOOL

The schedule for the 1981 At-Sea-Test does not allow sufficient time for the manufacture of a state-of-the-art sonar reentry tool. There is not even sufficient time for a factory overhaul of one of the nine existing sonar reentry downhole tools used in the DSDP program.

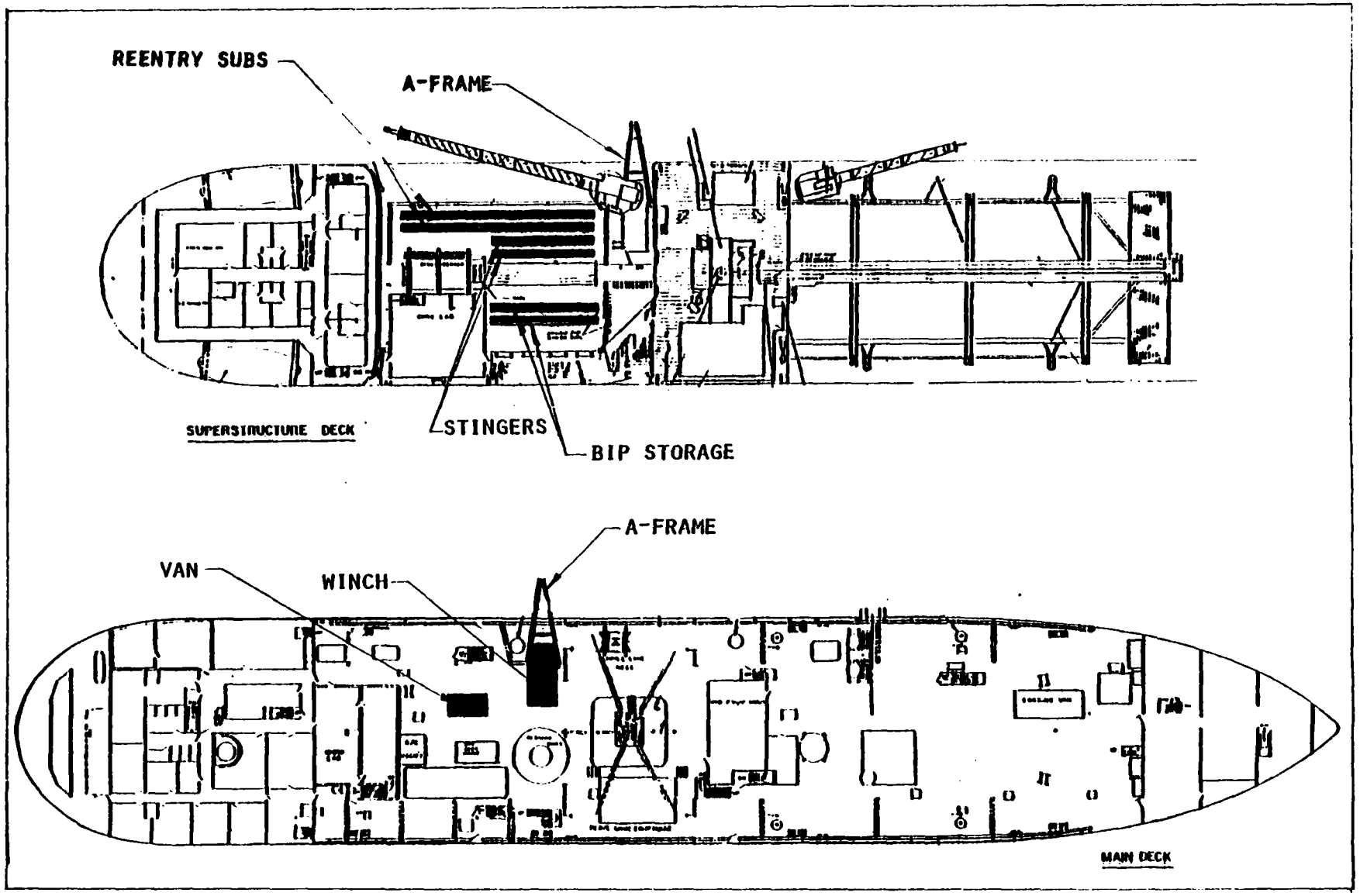


Figure 3-3. LOCATION OF MAJOR MSS TEST HARDWARE ON THE GLOMAR CHALLENGER

However, we are assured by the DSDP program office that:

- The complete reentry system aboard the GLOMAR CHALLENGER is in excellent condition and the sonar downhole tool and/or the deck monitoring equipment would not benefit by being overhauled at the factory.
- The system is of simple standard solid state electronic design and has had regular checking and maintenance to keep it at maximum design capability.
- The existing winch and cable are in excellent condition. The reentry tool used aboard the GLOMAR CHALLENGER is adequate for the 1981 reentry demonstration.

The newer sonar/tv reentry tool possesses many desirable advantages such as azimuth readout and should be seriously considered for the 1982 MSS Deployment Program.

The reentry tool will require an adaptor so that it can interface with the BIP stinger. The adaptor is necessary because the stinger inside diameter is 216 millimeters (8.5 inches) and the outside diameter of the sonar downhole tool is 94 millimeters (3.75 inches). The adaptor is shown on GMDI Dwg. D-001-A010, and the BIP stinger is shown on GMDI Dwg. D-001-A007.

Performance Capabilities of Present System (Similar to EDO-Western Model 516):

- Operating Depth: 6,096 meters (20,000 feet) (utilizing 7-conductor logging cables)
- Range: Maximum 152 meters (500 feet)
- Range Scales: 500, 250, 100, 50, 25 feet
- Operating Modes: Selector scan and full rotation
- Range Accuracy: $\pm$5% or 6 inches whichever is greater
- Range Resolution: 6 inches on 100 foot scale.

- Scan Rate:

Scale	Rate
25 ft	33.0°/sec
50	27.3°/sec
100	20.4°/sec
300	11.5°/sec
500	6.7°/sec

- Azimuth Scan Coverage: 360°
- Azimuth Accuracy: ±1°
- Azimuth Sector Scan Coverage (& Index Select): ±45°
- Cable: 7-Conductor - "logging cable"
- Housing: #7075 Aluminum housing and stainless steel collars for bearing surfaces and cathodic protection
- Max. Outside Diameter of Housing: 94 millimeters (3.75 inches)
- Connectors: Waterproof, quick-disconnect connector to match standard "logging" cable.
- Transducer Type: Lead Zirconate
- Power Output: 800 watts, 109 db source level, minimum
- Protection: Impact relief (break-away)

The existing hydroelectric winch is capable of holding 6,096 meters (20,000 feet) of 7-conductor logging cable. The winch has slip-rings, automatic level-wind, cable footage counter, local controls for 53 meters/minute(150 fpm) to 70 meters/minute (200 fpm) average speed at 4,535 kilograms (10,000 pounds) stall load at the drum.

3.8 CABLE TENSION

Tension will be imparted to the cable through the following mediums:

- Cable Weight - This tension will increase when deploying cable and decrease when hauling in. Weight can be established if related to the footage of cable deployed.
- Minimum Tension - This is to ensure that the EM Cable never goes into compression and should have a minimum value of about 680 kilograms (1,500 lbs).
- Current Drag - Tension can be added because of the catenary or curves set up in the EM Cable due to current drag.

- o Dynamic Motions of the Ship - This tension is due to the inertia of the weight of cable deployed and is proportional to the deployed cable length. It is greatest when the ship's roll, pitch, and heave synchronize.
- o Cable Extension - This is the cable stretch due to ship motions and will be greater at the start of cable deployment because of the absence of a catenary.

A preliminary study (See Appendix I-2) was made of the above tension sources and the possible forces that would be imparted to the cable which has 9,534 kilograms (21,000 pounds) breaking strength. The study neglects the dampening effect of the drag catenary or curves due to reversing currents and also neglects the spring constant in the cable. The maximum dynamic force calculated in the 6,096 meters (20,000 feet) of cable was 1,150 kilograms (2,540 pounds) for combined pitch, roll and heave. This was for Sea State 5.

Added to this are the loads due to cable weight, minimum winch tension, current drag induced tension and cable stretch due to pitch and roll. For the 6,096 meters of cable this gives a maximum tension of 5,270 kilograms (11,958 pounds). This value should be reduced because of the catenary and spring constant in the cable and in the case of the At-Sea-Test deployment demonstration due to the shorter cable, 4,570 meters (15,000 feet). A more rigorous analysis will be conducted to verify the dynamic loads and to define any localized resonance condition.

The estimates in Appendix I-2 are conservative because they assume rigid connections, no catenary, no dampening and all dynamics forces acting at once. However, these preliminary results demonstrate that a constant tension winch with a fast response time is necessary so that the tension in the cable does not exceed the maximum permissable.

This study will be further refined as we get more accurate input on the EM winch tensioning characteristics. Dynamic compensation equipment appears will be provided to augment the current winch supplied tensioning equipment.

3.9 TOLERANCES OF CASING AND REENTRY STINGER

The tolerances of the casing and the casing hanger are of critical nature. The cone assembly used at site 395A has 28 centimeters (11 inches) nominal casing with a casing hanger. Minimum casing ID is 27.2 centimeters (10.72 inches) as per casing handbook and the casing hanger has a minimum ID of 28.1 centimeters (11.06 inches). The elliptical distortion is unknown, therefore we assume that the casing was drifted per American Petroleum Institute (API) Specification 5A, Page 34. This drift minimum diameter is 27.09 centimeters (10.664 inches).

The reentry stinger was designed to keep very close to the minimum ID of this casing, here the controlled diameter of the stinger end is 26.67 $\pm$ 0.15 centimeters (10.50 $\pm$ 0.06 inches). This fit minimizes any tendency of the EM Cable to wedge between the casing and stinger impact end.

We have provided vertical strips of rubber at the upper section of the stinger to help centralize this section in the casing hanger area. The rubber strips are designed to fill the gap between the stinger and the casing hanger. Using minimum IDs and maximum stinger diameters there would be a maximum total compression force of 1,843 kilograms (4,060 pounds) to compress the rubber its full length.

SECTION 4.0 - AT-SEA-TEST OPERATIONS

4.1 OPERATIONAL SCENARIO

The preliminary operational scenario for the deployment and recovery of the At-Sea-Test BIP is shown by Figures 4-1 through 4-14. Total estimated accumulated time is approximately 108 hours. This does not allow for weather holds and/or equipment failure/repair delays.

This scenario in preliminary form has been presented to the DSDP Project Office and GMDC. Details of the scenario will be coordinated with them. Minor procedural changes will be implemented as the hardware is fabricated and actual test data becomes available. The final operational procedures will be submitted under separate cover as GMDI Report RPT-006-003.

AFTER THE HOLE IS CLEANED OUT AND LOGGED FOR SCIENTIFIC DATA, APPROXIMATELY 100 FT. OF CEMENT PLUG*IS SET IN BOREHOLE FROM 500 FT. TO 400 FT. DEPTH. DP IS RETRIEVED.

* CEMENT PLUG WAS DELETED IN SUBSEQUENT DESIGN REVIEW.

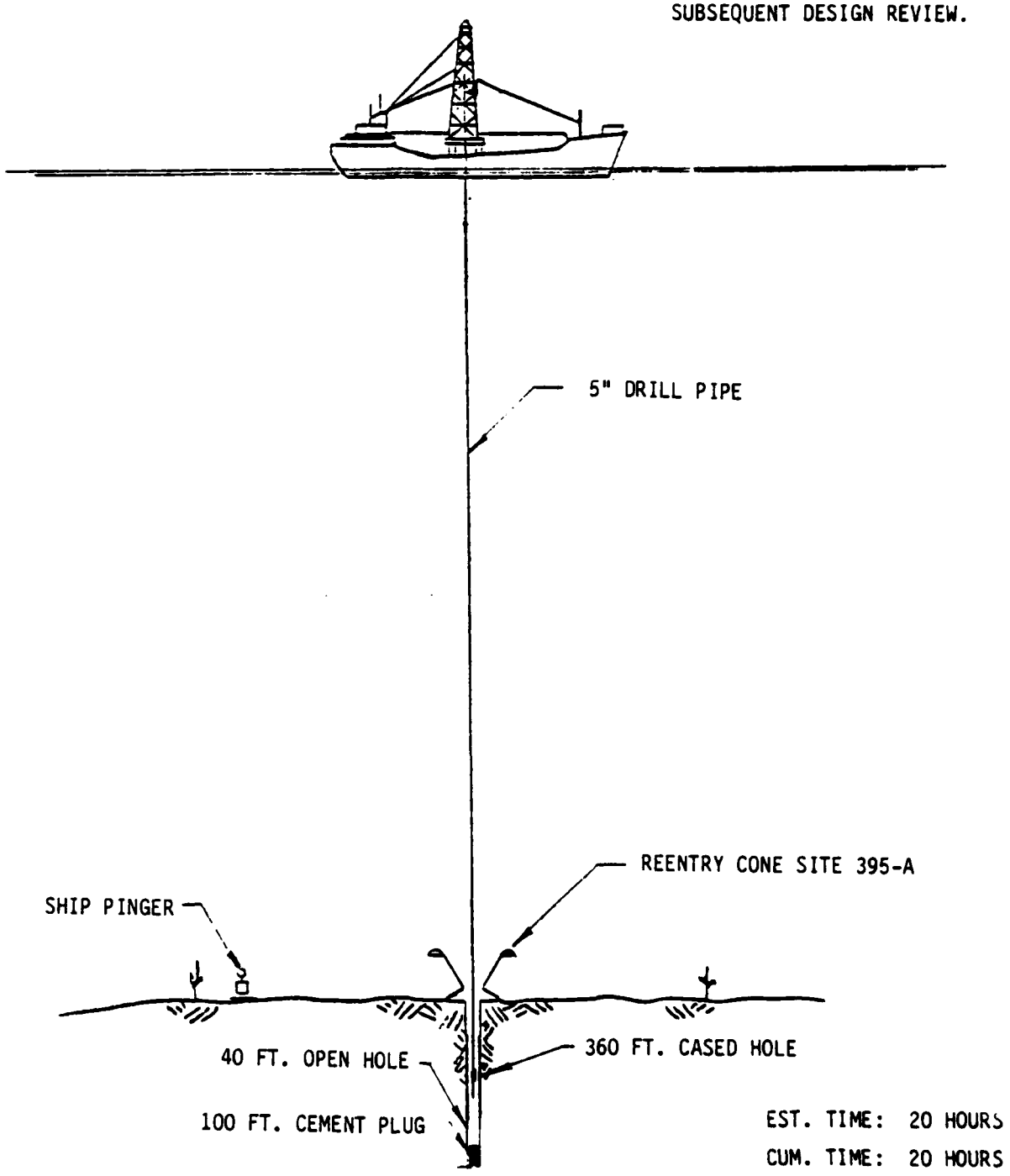


FIGURE 4-1 - MSS AT-SEA-TEST - SEQUENCE 1

BIP IS INSTALLED IN BIP REENTRY SUB AT RIG FLOOR, NAVY SUPPORT VESSEL PROVIDES CURRENT DATA.

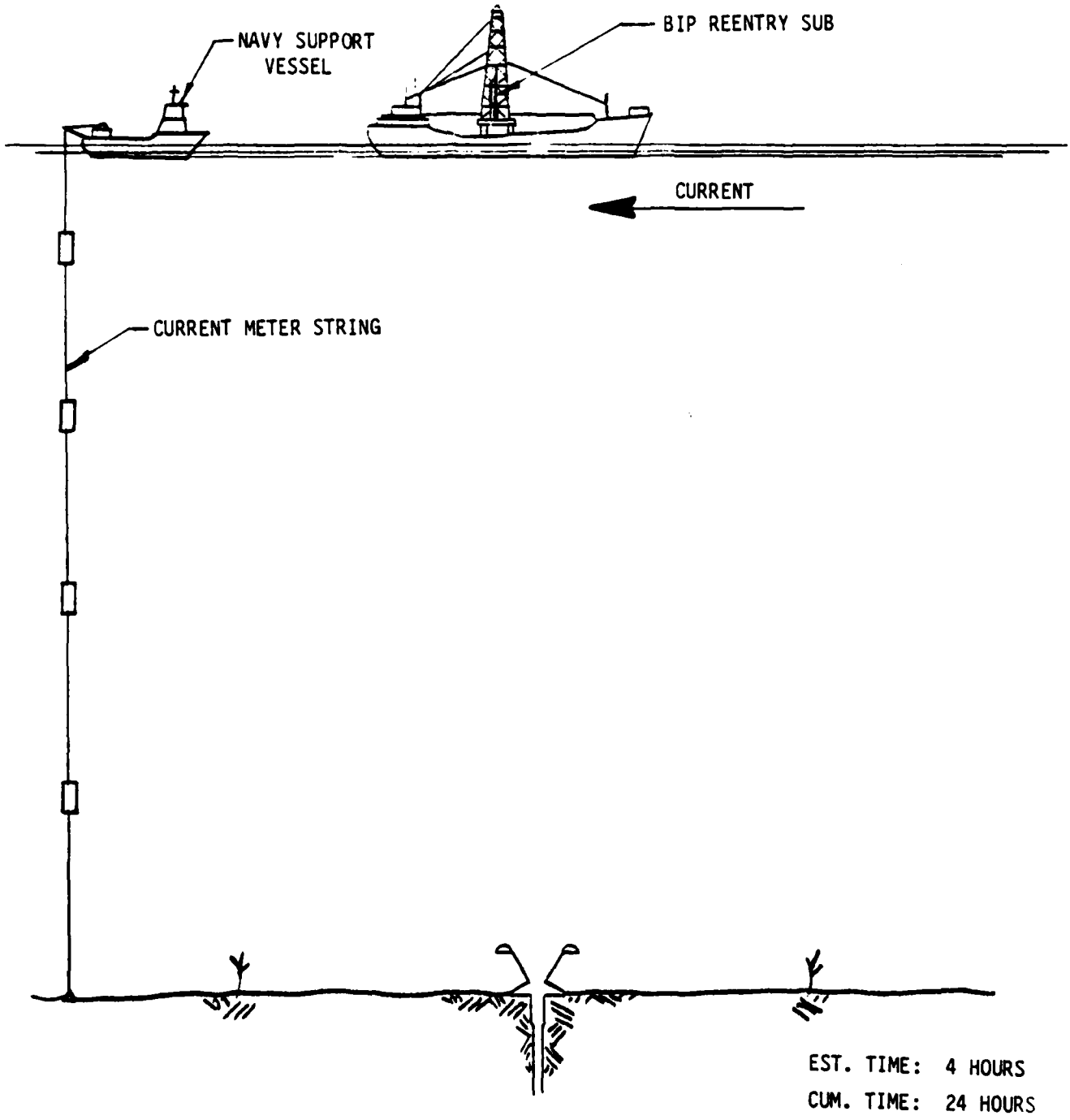
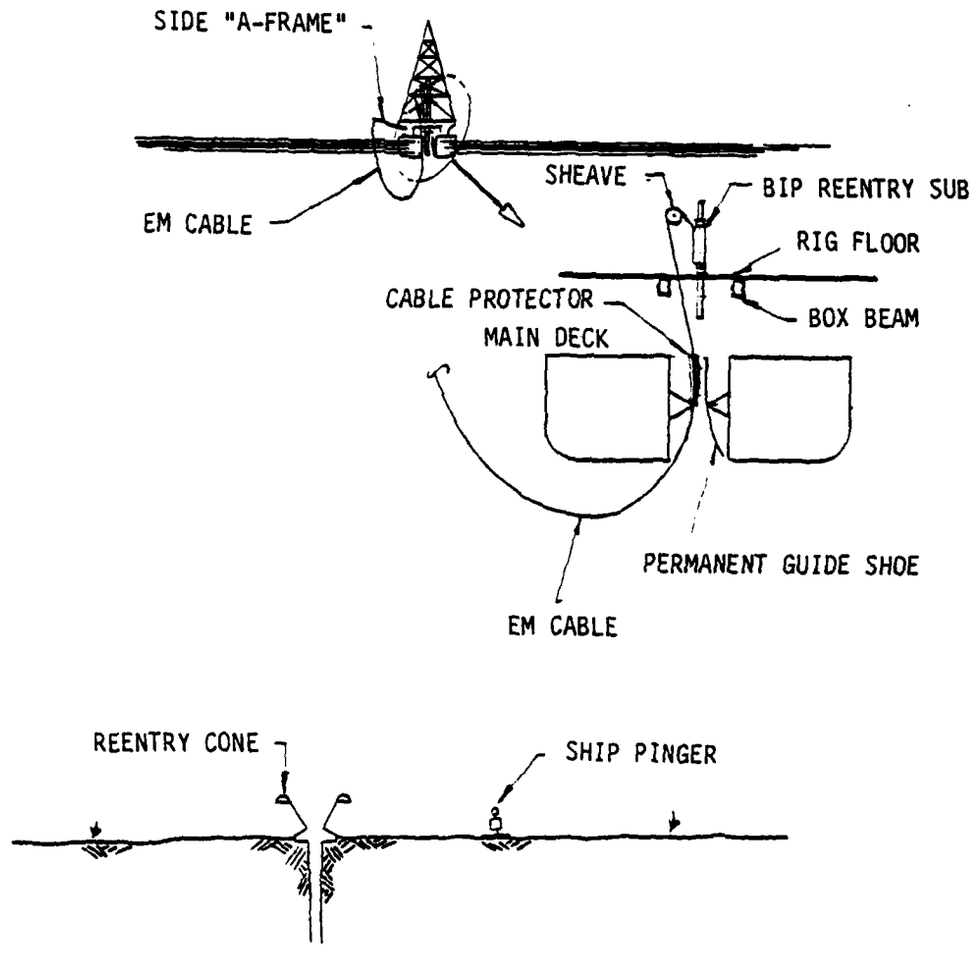


FIGURE 4-2 - MSS AT-SEA-TEST - SEQUENCE 2

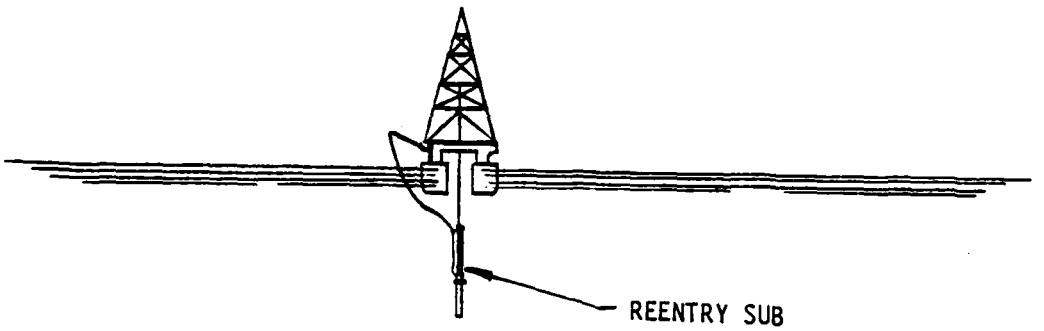
EM CABLE IS KEEL HAULED THROUGH MOON POOL UP TO RIG FLOOR AND CONNECTED TO BIP.

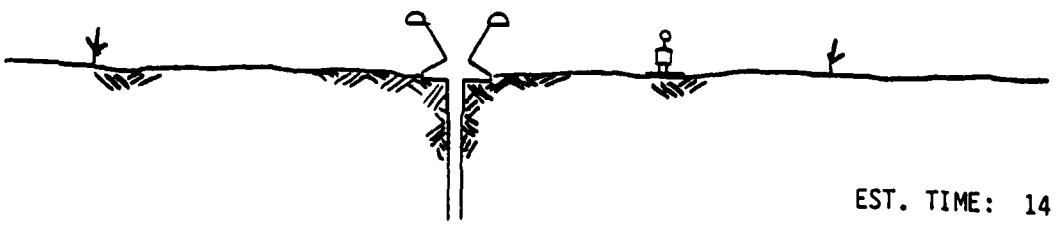


EST. TIME: 6 HOURS
CUM. TIME: 30 HOURS

FIGURE 4-3 - MSS AT-SEA-TEST - SEQUENCE 3

BIP REENTRY SUB IS LOWERED WITH REENTRY ASSEMBLY (SEE FIGURE 4-5) AND DRILL PIPE. TENSION IS MAINTAINED ON EM CABLE. DP IS KEPT IN FIXED ORIENTATION (NO ROTATION ALLOWED) WHILE MAKING UP JOINTS.





EST. TIME: 14 HOURS
CUM. TIME: 44 HOURS

FIGURE 4-4 - MSS AT-SEA-TEST - SEQUENCE 4

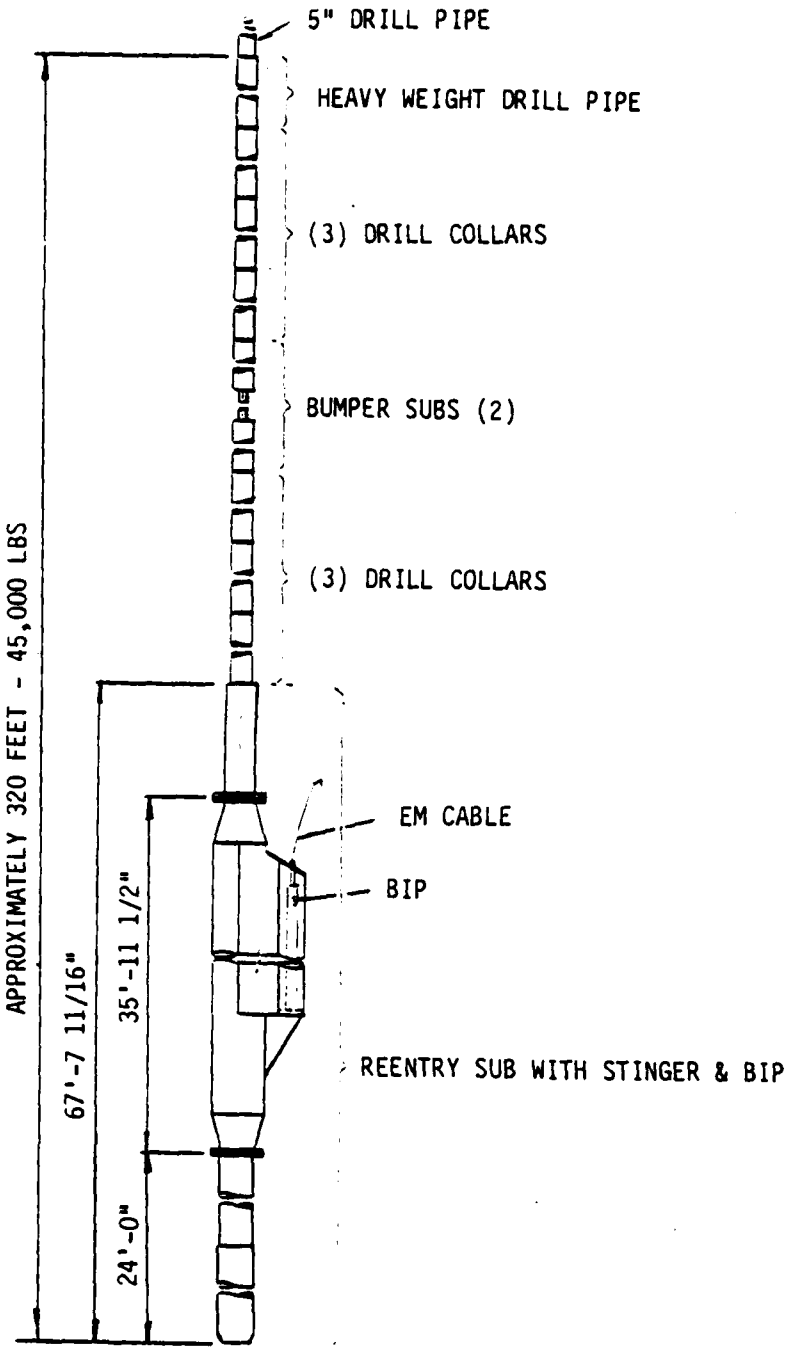


FIGURE 4-5 - TYPICAL BIP REENTRY ASSEMBLY

WHEN BIP REENTRY SUB IS ABOUT 30 FEET ABOVE BOTTOM, SONAR REENTRY TOOL IS LOWERED TO LOCATE THE CONE.

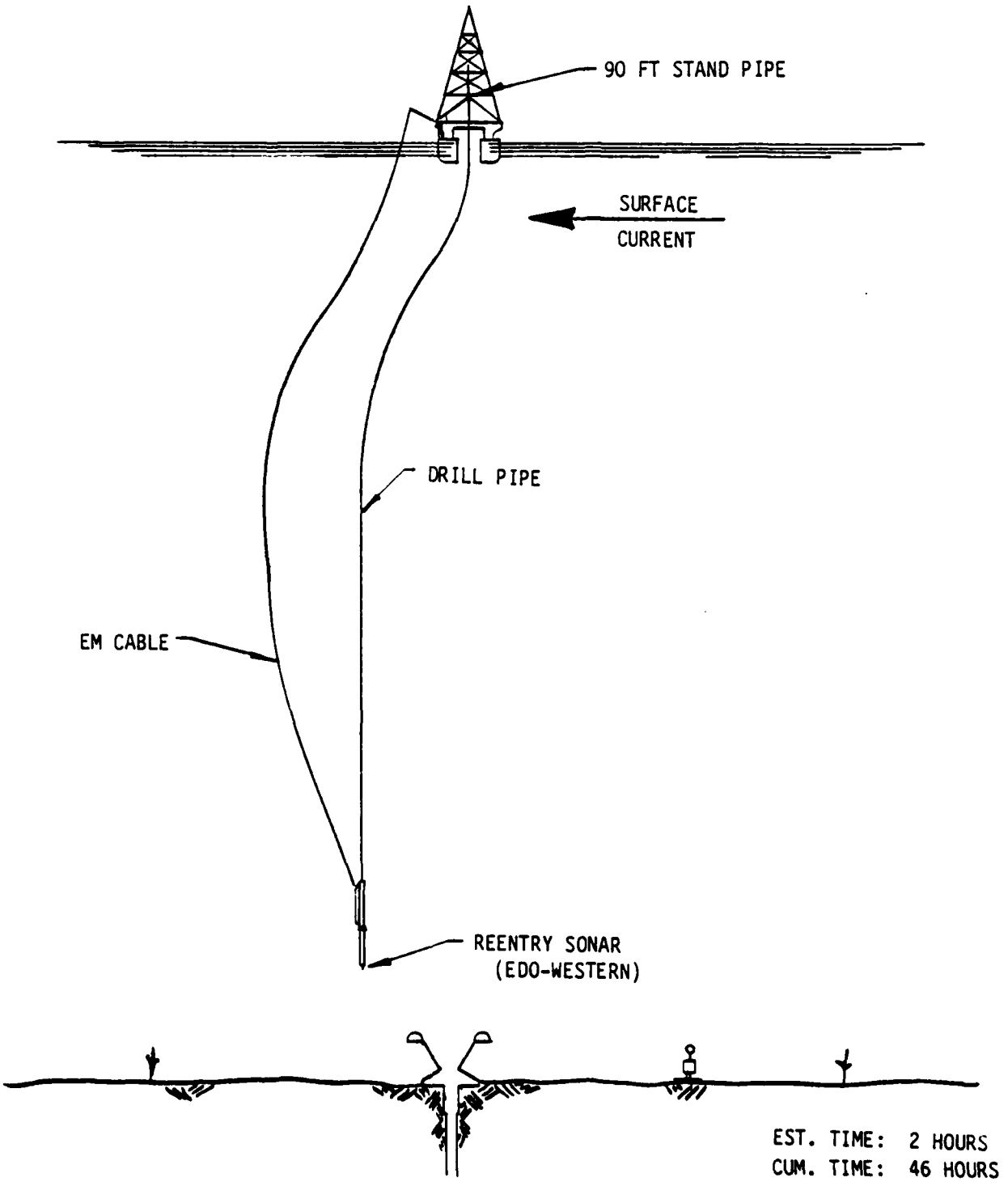


FIGURE 4-6 - MSS AT-SEA-TEST - SEQUENCE 5

APPROXIMATELY 90 FEET OF EM CABLE IS PAID OUT. REENTRY IS MADE BY MANEUVERING VESSEL PER STANDARD PROCEDURES. IMPACT LOADING DURING REENTRY IS RECORDED. A TOTAL OF TEN REENTRIES ARE MADE AND DATA RECORDED.

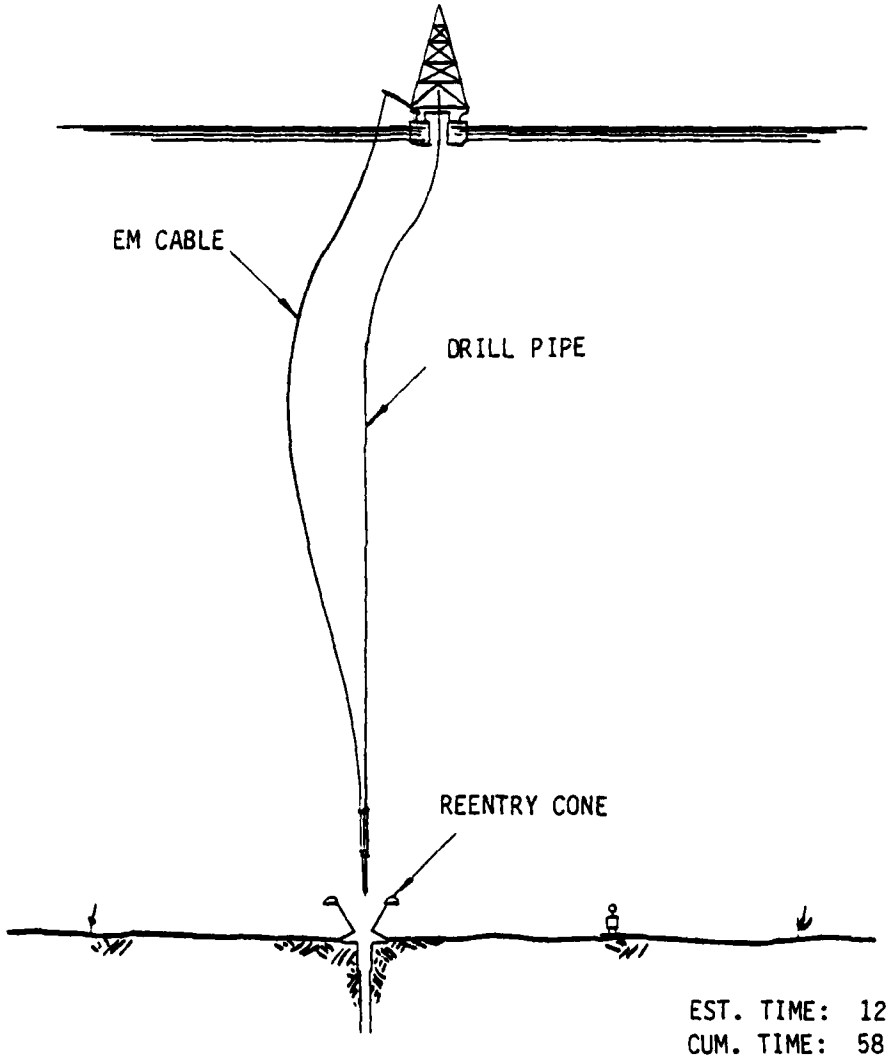


FIGURE 4-7 - MSS AT-SEA-TEST - SEQUENCE 6

SONAR TOOL IS RETRIEVED. A FISHING TOOL WITH BAKER LOCK SUBASSEMBLY IS SENT DOWN THROUGH DP. HYD/SONAR ADAPTOR IS RAISED AND LATCHED ABOVE THE REENTRY SUB. FISHING TOOL IS RETRIEVED.

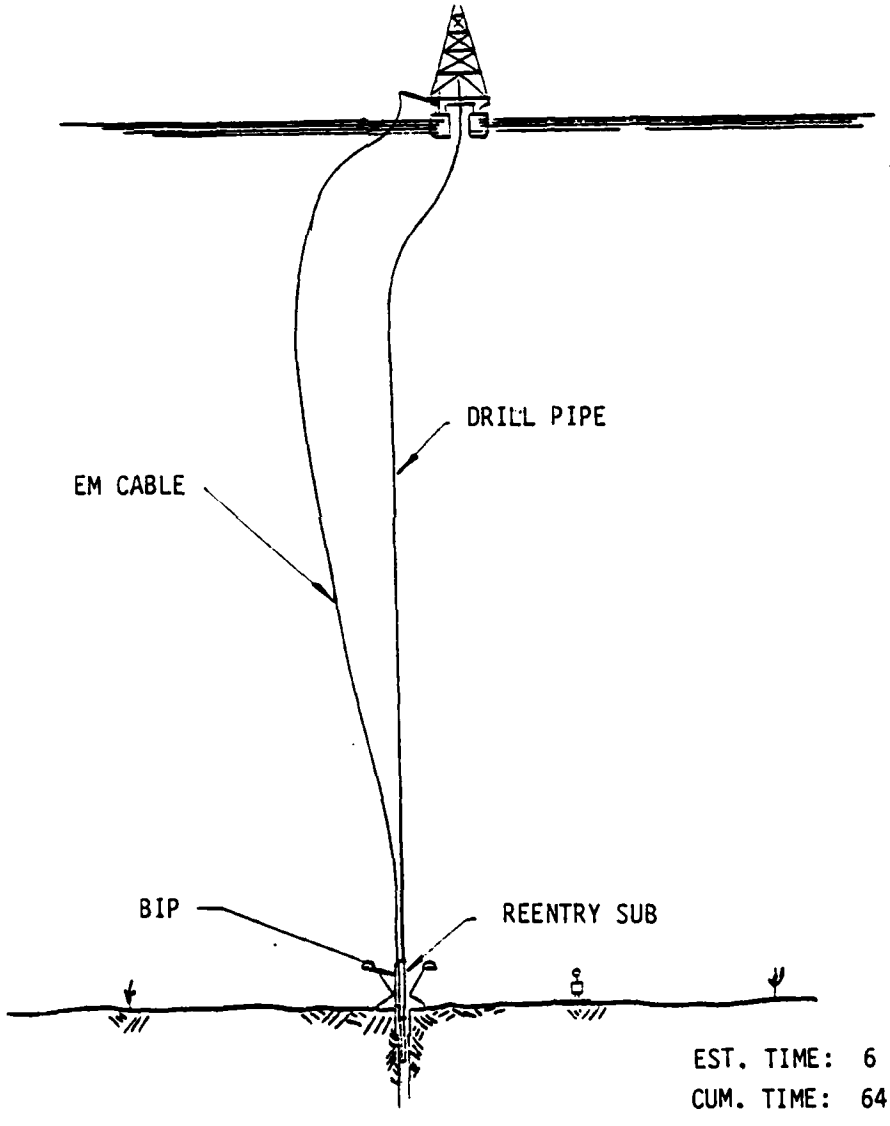
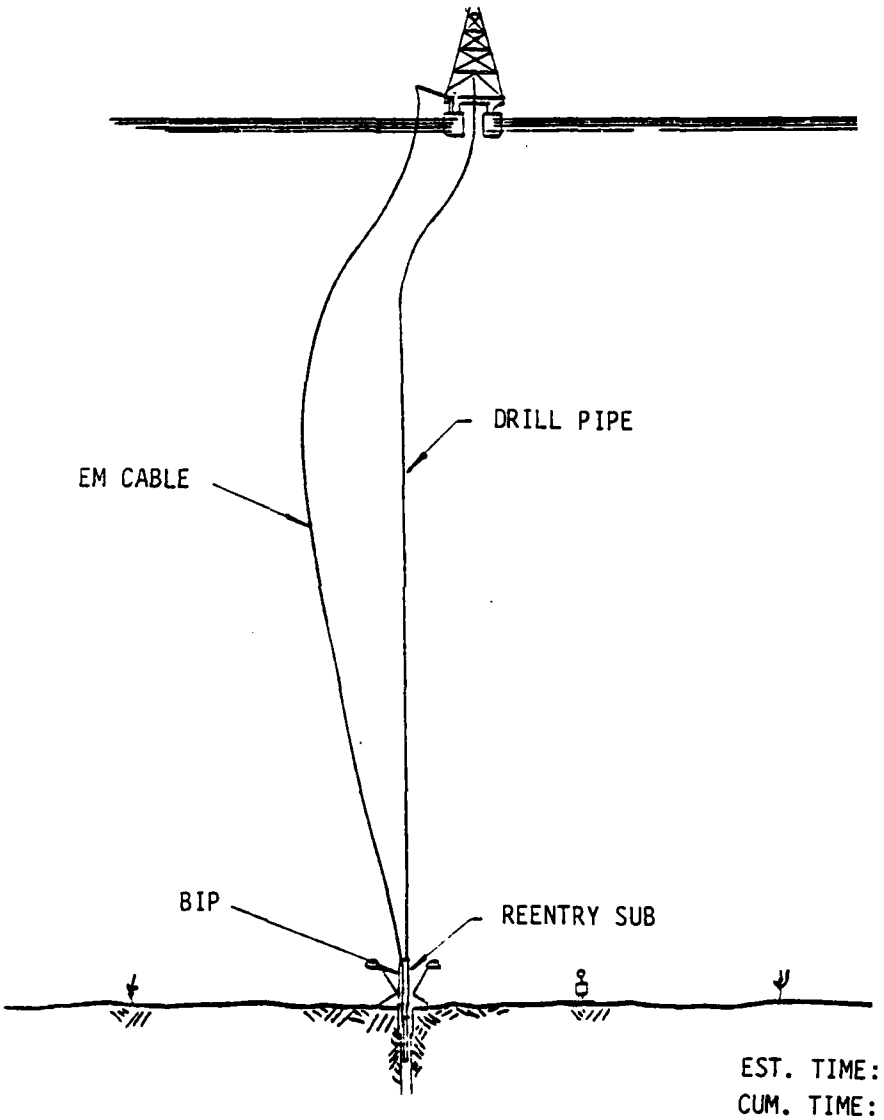


FIGURE 4-8 - MSS AT-SEA-TEST - SEQUENCE 7

TENSION ON EM CABLE IS INCREASED TO OFFSET WEIGHT OF BIP. BIP IS CENTERED IN REENTRY SUB AND RELEASED BY HYDRAULIC PRESSURE FROM RIG FLOOR THROUGH DP.



EST. TIME: 2 HOURS
CUM. TIME: 66 HOURS

FIGURE 4-9 - MSS AT-SEA-TEST - SEQUENCE 8

BIP IS LOWERED ABOUT 300 FEET INTO BOREHOLE. DRILL PIPE IS RAISED ABOUT 90 FEET ABOVE CONE. CABLE RETAINING GATE IN REENTRY SUB IS OPENED BY HYDRAULIC PRESSURE FROM RIG FLOOR. DP IS ROTATED 180° CLOCKWISE AND COUNTER CLOCKWISE TO ALLOW CABLE TO FALL OUT OF REENTRY SUB.

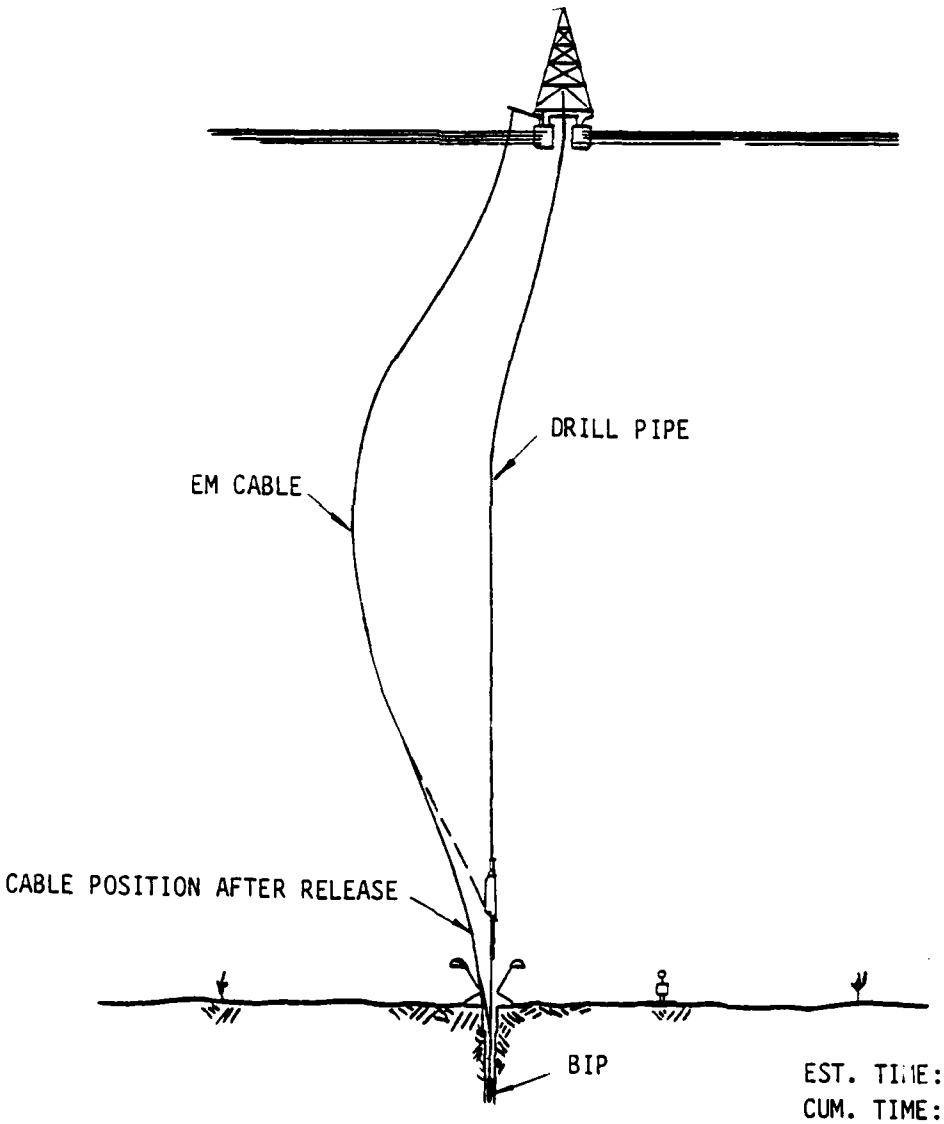
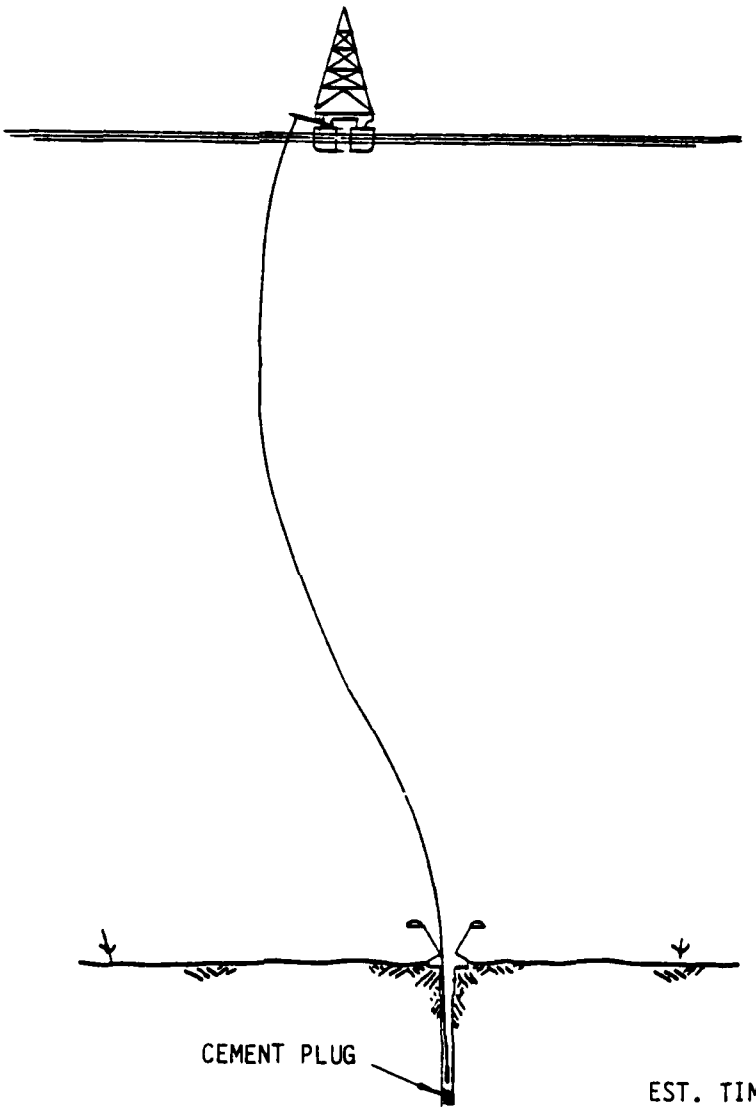


FIGURE 4-10 - MSS AT-SEA-TEST - SEQUENCE 9

DP IS RETRIEVED. BIP IS SET ON TOP OF CEMENT PLUG.



EST. TIME: 8 HOURS
CUM. TIME: 76 HOURS

FIGURE 4-11 - MSS AT-SEA-TEST - SEQUENCE 10

VESSEL IS MOVED ABOUT 5,000 FEET AND EM CABLE PAID OUT. VESSEL IS HELD ON LOCATION FOR 24 HOURS AND SEISMIC DATA RECORDED.

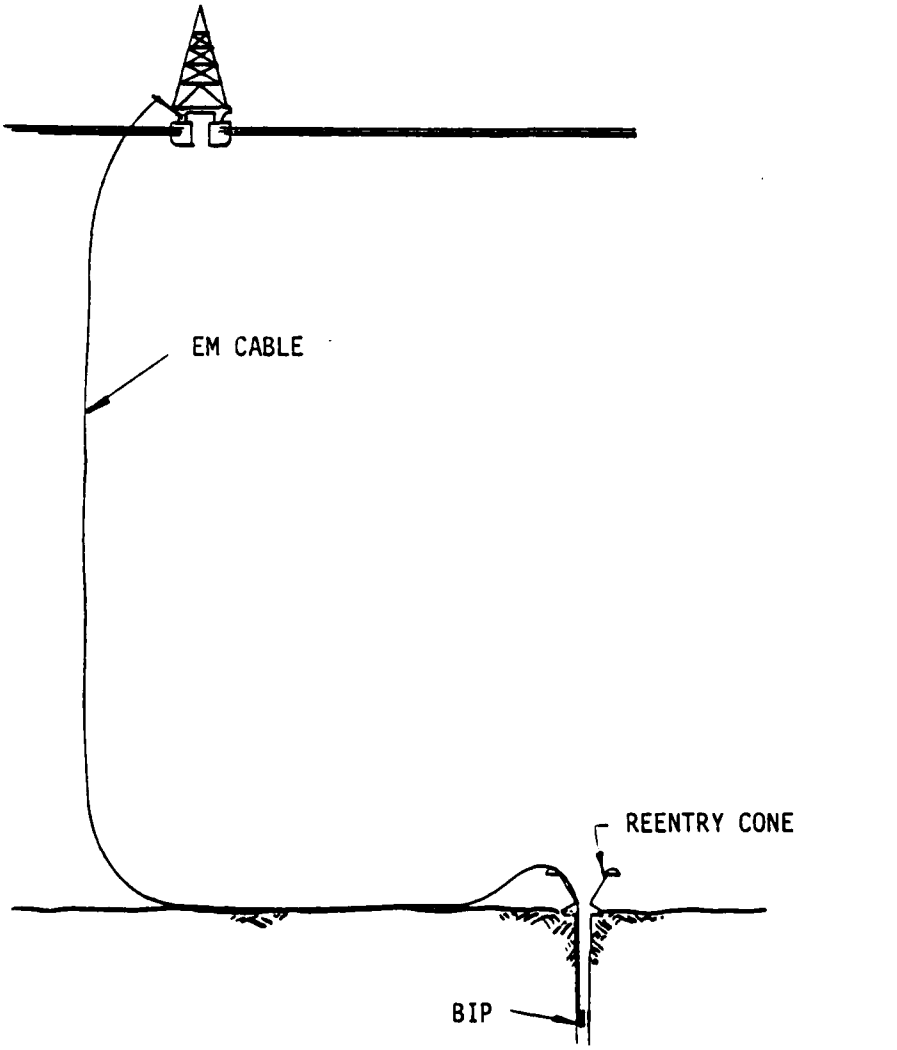
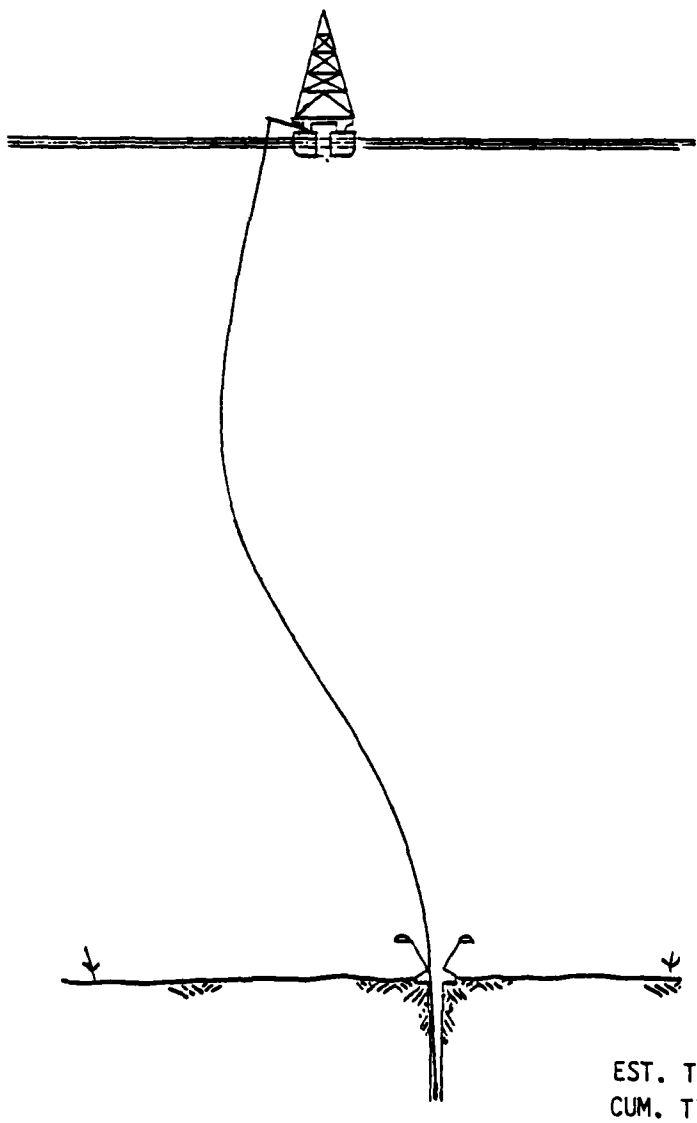


FIGURE 4-12 - MSS AT-SEA-TEST - SEQUENCE 11

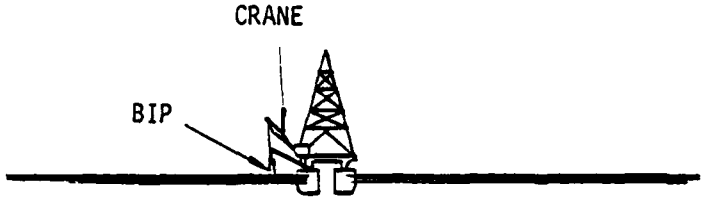
EM CABLE IS PULLED IN AS VESSEL MOVES TOWARDS REENTRY CONE.



EST. TIME: 2 HOURS
CUM. TIME: 104 HOURS

FIGURE 4-13 - MSS AT-SEA-TEST - SEQUENCE 12

BIP AND EM CABLE ARE RETRIEVED. BIP IS HANDLED ON BOARD BY 50 TON CRANE.



EST. TIME: 4 HOURS
CUM. TIME: 108 HOURS

TOTAL ESTIMATED TIME: 4 1/2 DAYS

FIGURE 4-14 - MSS AT-SEA-TEST - SEQUENCE 13

SECTION 5.0 - AT-SEA-TEST MOBILIZATION

5.1 GENERAL

Mobilization for the At-Sea-Test is intended to provide the means to procure, deliver, test and install the necessary primary and support equipment for the conduct of the At-Sea-Test. An At-Sea-Test mobilization plan has been prepared (Appendix C) which compiles available information which bears upon the delivery of equipment from various suppliers, and its subsequent transportation to the industrial activity in San Juan, Puerto Rico. In San Juan, a special receiving and test facility will be set up. The equipment will be installed aboard the GLOMAR CHALLENGER. Detailed schedules are being prepared to follow all elements of the procurement and mobilization.

The exact final installation time and location is currently undecided. The current DSDP GLOMAR CHALLENGER schedule provides for an early 5-day port stop in San Juan starting January 23, 1981 and only a one-half day port stop on February 2., 1981 in Martinique. The final installation of MSS equipment will take at least two days to accomplish. Also, there will be major shipping costs, shipment delays and customs factors to be considered if this final installation must be performed in Fort-de-France, Martinique. NORDA has requested return of the GLOMAR CHALLENGER to San Juan preparatory to transiting to the test site.

The plan must organize the above elements to meet the time constraints of the ship's active operating schedule in such a way that the normal operations of the deep sea drilling project will be impacted upon to the least possible extent.

Preliminary liaison has been established with the various equipment manufacturers and suppliers, and the design requirements of the equipment have been made known. Surface and air transportation companies have been contacted to establish probable routing and schedules. Industrial marine activities in San Juan, Puerto Rico; Fort-de-France, Martinique, and Las Palmas, Gran Canaria, have been

contacted to ascertain the availability of craftsmen, manpower and equipment to carry out the installation of primary and support At-Sea-Test equipment and its removal in the demobilization phase.

The enclosed mobilization plan is to be distributed concurrently to all appropriate organizations involved with the At-Sea-Test. It will be updated periodically to reflect new data and changes to the At-Sea-Test Program.

5.2 DEPLOYMENT EQUIPMENT PROCUREMENT

The deployment equipment which is to be furnished by GMDI is to be procured through the normal process which has been established within the GMDI organization for the procurement of goods and services. Table 5.1 shows estimated purchase order and delivery dates for planning purposes.

The equipment of this category includes:

- The two reentry subs, made up of a BIP carriage control sub, a BIP carriage housing, a reentry tool stinger and a hydraulic plug/sonar adapter. In addition, there will be:
 - Dynamic tensioning equipment
 - A Baker 4-inch model "K" lock subassembly
 - A 10-ton capacity "A-Frame"
 - EM Cable Winch Foundation
 - Miscellaneous handling equipment, tools and fittings

5.2.1 Reentry Sub

The final design of the reentry sub has been completed and a Request for Bid has been sent to five prospective suppliers. When all bids have been received, an evaluation of the bids will be made and a selection of a fabricator made based upon that evaluation. A Requisition for Purchase will be completed and a Purchase Order issued for fabrication in accordance with GMDI drawings and specifications. The Purchase Order will also direct that the two reentry subs be shipped to the Trailer Marine Transport Terminal, Jacksonville, Florida, not later than February 2, 1981 in order to

TABLE 5.1

TYPICAL PROCUREMENT AND DELIVERY SCHEDULE

EQUIPMENT	PROCUREMENT	DELIVERY	REMARKS
REENTRY SUBS #1 & #2	OCT 15, 1980	JAN 15, 1981 & NLT FEB 2, 1981	#1 TO BE DELIVERED TWO WEEKS PRIOR TO #2
DYNAMIC TENSIONING EQUIPMENT	NOV 1, 1980	JAN 15, 1981	REQUIREMENTS TO BE IDENTIFIED IN PHASE III
BAKER 4" MODEL "K" LOCK SUBASSEMBLY	OCT 7, 1980	NOV 30, 1981	SHELF ITEM
10 TON CAPACITY "A-FRAME" AND EM CABLE WINCH FOUNDATION	OCT 15, 1980	JAN 15, 1981	TO BE FABRICATED BY PRDD & MT IN SAN JUAN - SOLE SOURCE
MISC. HAND EQUIPMENT	NOV 1 - DEC 1, 1980	NLT FEB 2, 1981	PURCHASED WHEN IDENTIFIED

reach San Juan, Puerto Rico and, if necessary, Fort-de-France, Martinique by February 27, 1981. In the event that the surface shipping deadline date of February 6, 1981 cannot be met, back-up charter air freight has been investigated and will be arranged.

5.2.2 Baker 4-Inch Model "K" Lock Subassembly

This equipment has been specified by GMDI engineering and will be procured through Baker Packers, 7400 E. Slauson Avenue, Los Angeles, California 90051, as sole source. The Purchase Order will direct shipment to the Trailer Marine Transport Terminal (TMT), Jacksonville, Florida prior to February 2, 1981 in order to be available in San Juan or Fort-de-France by February 27, 1981.

5.2.3 Ten Ton Capacity "A-Frame"

The contract for fabrication of this equipment will be given to Puerto Rico Drydock and Marine Terminals, Inc. (PRDD&MT). In this case, consideration has been given to the fact that this shipyard is the best choice, as a fully-capable marine facility, for the installation of the deployment equipment aboard ship and for the accomplishment of consequent ship modifications. The selection of that facility is therefore a logical one. Fabrication locally in San Juan is also considered expedient because it will simplify shipment costs and procedures. A Purchase Order will be issued to Puerto Rico Drydock and Marine Terminals, Inc. directing fabrication of the "A-Frame" in accordance with GMDI drawings and specifications and directing delivery by January 15, 1981.

5.2.4 Miscellaneous Handling Equipment, Tools and Fittings

This equipment will be procured either through sole source or by competitive bid when identified in relationship to engineering considerations.

The following is a list of miscellaneous equipment which has been identified:

- o Cable Protector - 2" x 5' XXS pipe split and hinged
- o EM Cable Self-Locking Snatch Block - 36" diameter
- o Survey tools for pipe alignment
- o Baker Model "K" Lock Subassembly (2)
- o Baker Special Blank Bottom Adapter (2)
- o Baker Model "M1" Probe (1)
- o Otis Fishing Tool (2)
- o Head Sets
- o Handling Sling for BIP
- o Handling Sling for Reentry Sub
- o Vertical Mounting Fixture for BIPs
- o Rack for Reentry Subs
- o EM Cable Handling Sleeve Attachment
- o Keelhaul Line for EM Cable
- o "A-Frame" Self-Locking Snatch Block - 36" diameter with tension readout attachment fitting.
- o Running Fairleader with mechanical/acoustic release
- o Tools

5.3 MOBILIZATION/DEMOBILIZATION

5.3.1 Mobilization

This subsection discusses the disposition of all of the deployment equipment after the procurement phase and subsequent to its delivery to the Trailer Marine Transport Terminal in Jacksonville, Florida. This equipment includes:

- o Two reentry subs including BIP release tools furnished by GMDI.
- o Baker 4" model "K" lock subassembly furnished by GMDI.
- o Miscellaneous handling equipment, tools and fittings furnished by GMDI.
- o Two BIP furnished by Geotech.
- o BIP control console van furnished by Geotech.
- o EM Cable winch and EM Cable both furnished by Geotech.

All equipment will be consolidated in a TMT Trailer to meet as closely as possible, a minimum 24,000 lb shipping rate. Consideration must be given to delivery dates in Florida and installation time frames in San Juan (or Martinique). Shipments leave Jacksonville three days per week. Transit time to San Juan is four days. If it is not possible for the ship to return to San Juan from Fort-de-France, about February 27, 1981, then the deployment equipment will have to be transported to Fort-de-France via TMT barge. Shipping dates from San Juan to Fort-de-France are January 2, 16, 30 and February 13, 1981. Transit time is six days.

An examination of these dates indicates that the deployment equipment should arrive in San Juan no later than the first week in February, in order to be available for installation on February 27, 1981. If the ship does return to San Juan as requested, the shipping schedule can be somewhat more flexible. However, every effort will be made to ship the deployment equipment to arrive in San Juan the first week in February so as to provide time for inspection, preparation and test prior to installation on the ship.

Table 5.2 is provided as a compilation of information available concerning shipment of deployment equipment.

For equipment which will not be delivered in sufficient time to make surface transportation schedules, air freight, both regular and charter has been investigated and will be arranged.

A receiving and test facility will be opened in San Juan at the PRDD&MT shipyard about January 15, 1981. The facility will have office space, a storage and assembly area, forklift trucks, a crane and other handling equipment.

From this facility, GMDI personnel will direct and control the installation of the EM Cable winch foundation, the BIP control console van foundation and the "A-Frame" and the installation of all necessary power and lighting cabling, during the period January 23 - 28 1981 in San Juan.

TABLE 5.2

SHIPMENT OF DEPLOYMENT EQUIPMENT

EQUIPMENT	FURNISHED BY	DATE ARRIVAL JACKSONVILLE	AIR FREIGHT SHIPMENT PROBABLE	DATE ARRIVAL SAN JUAN	REMARKS
BIP (2)	Geotech	Late Jan '81	No	Middle Feb '81.	Information not available
BIP STC Van	Geotech	Late Jan '81	No	Middle Feb '81	Information not available
EM Cable Winch & EM Cable	NORDA	Late Jan '81	No	Middle Feb '81	Information not available
Reentry Sub #1	GMDI	Late Jan '81	No	Middle Feb '81	Long lead time
Reentry Sub #2	GMDI	Late Jan '81	No	Middle Feb '81	Long lead time
4' Model "K" Lock Subassembly	GMDI	Early Jan '81	No	Middle Jan '81	Requisition completed
Aux Tension Equip	GMDI	Early Jan '81	No	Middle Jan '81	Not yet identified
Miscellaneous Handling Equip, Tools, etc.	GMDI	Dec - Jan '81	No	Dec - Jan '81	Not yet identified

It will also be used in the same way for the readiness, test and installation of the deployment equipment, late February or early March in San Juan or February 27, 1981 in Fort-de-France if required.

5.3.2 Demobilization

Demobilization will take place in Las Palmas, Gran Canaria at the Astilleros Canarios Shipyard about March 23 - 30, 1981. All equipment, foundations and cabling installed in San Juan will be removed and shipped to the respective owners in the United States or scrapped, as appropriate.

Customs regulations in Las Palmas have been investigated and are discussed in the Mobilization Plan, Appendix C.

SECTION 6.0 - MSS DEPLOYMENT PROGRAM PLAN

6.1 OVERALL PLAN

6.1.1 Introduction

An overall program plan was initially developed during Phase I and was further refined during Phase II. The intent of this plan was to guide the technical effort and provide applicable cost projections. The overall program encompasses five phases covering a period of about three and one-half years. The five phases are:

PHASE	ACTIVITY
I	Feasibility Study
II	Analyses, Test Planning and At-Sea-Test Design
III	Test Program and Final Configuration I Design
IV	Configuration I Mobilization and Deployment
V	Configuration II Mobilization and Deployment

The deployment activities encompass drilling the borehole, setting the borehole casing with reentry cone, installation of the BIP, and installation of the associated mooring, power, control and communication equipment.

6.1.2 Schedule and WBS

Figure 6-1 indicates the scope of the overall program schedule based upon tentative deployment in the North Pacific area during the June-July 1982 and 1983 periods. Figure 6-2 presents a work breakdown structure that can be used throughout all phases of the program.

6.1.3 Program Elements

The Phase I feasibility study essentially consisted of a conceptual design effort, and initial planning activity, plus a Rough Order of

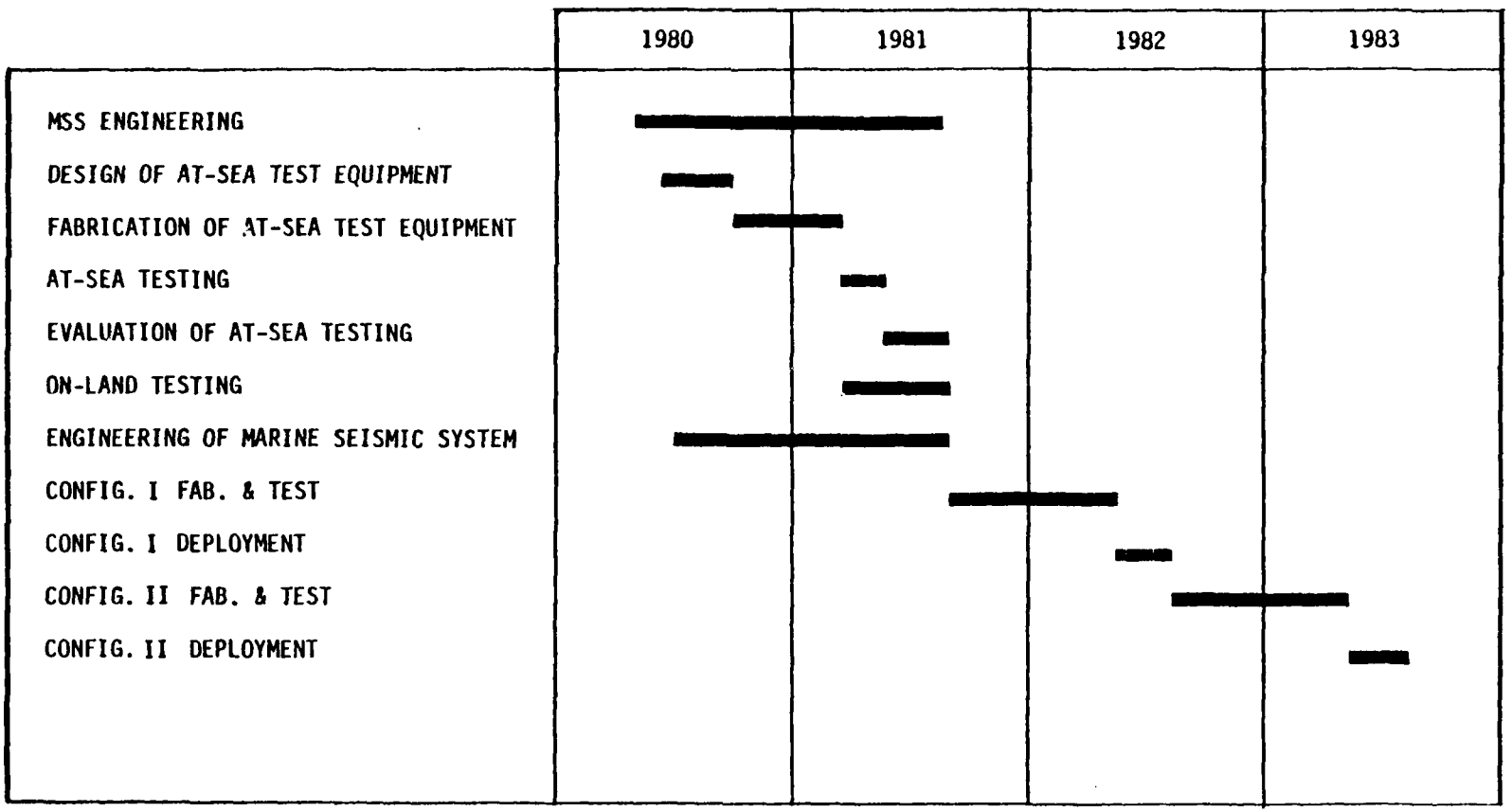


FIGURE 6-1. MARINE SEISMIC SYSTEM PROGRAM SCHEDULE

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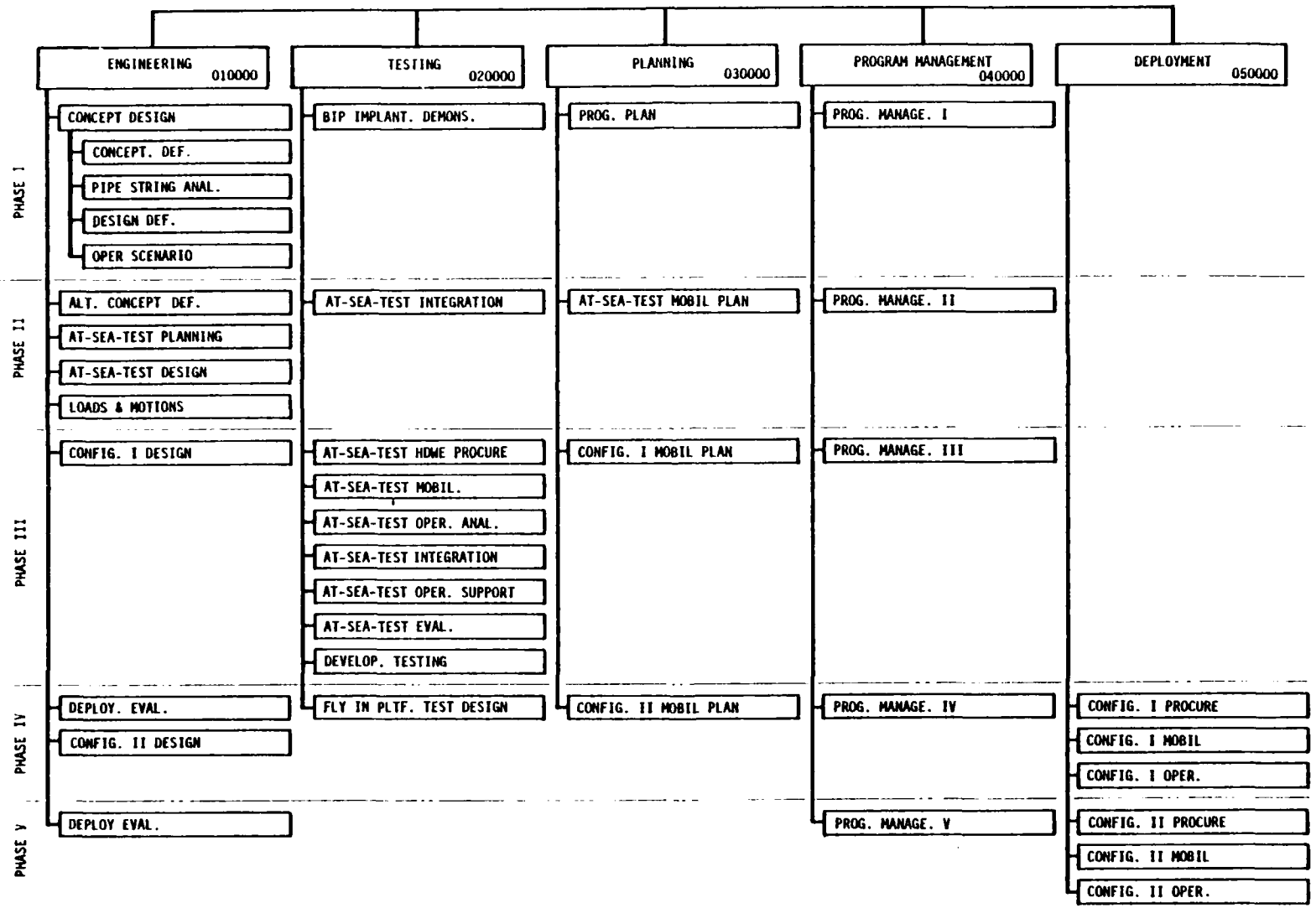


FIGURE 6-2. MSS DEPLOYMENT PROGRAM WORK BREAKDOWN STRUCTURE

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Magnitude (ROM) cost estimate. The Phase I report summarized the work accomplished to date in that phase and provided overall guidance for subsequent activities.

The Phase II effort concentrated on the design of equipment for the initial at-sea-test demonstration utilizing the GLOMAR CHALLENGER. This activity started with the development of the necessary test criteria for both at-sea and onshore development tests. Based upon this criteria, detailed designs for the baseline at-sea-test concept were prepared. The baseline design addresses reentry utilizing a drill pipe.

After review by NORDA, the final drawings and equipment specifications were released for vendor selection. In parallel, detailed planning for the at-sea-test was initiated including formulation of a fabrication, checkout, and mobilization plan. Detailed cost estimates for the at-sea-test equipment were prepared. In addition, a small analytical effort was undertaken to better determine the loads, motions, forces and pipe string stress levels for the drilling, casing installation and reentry operational subphases.

The initial Configuration I test plans has been distributed for comment.

A limited alternate reentry concept evaluation assessed state-of-technology for deep ocean guideline and fly-in deployment approaches. The fly-in platform approach has been selected for further Configuration II design studies.

Phase III is initiated by the authorization to procure the necessary at-sea-test equipment. In addition, the detailed test operational procedures plus installation requirements will be developed in conjunction with the DSDP Project Office and coordinated with NSF.

The actual at-sea-tests are tentatively scheduled for the Spring of 1981. From this test, final verification data concerning impact loadings, cable entanglement and operational procedures will be

developed. Concurrently, specialized planning for the onshore development testing will be initiated. This onshore testing will be oriented toward verifying the compatibility and reliability of the deployment equipment and processes under simulated deep ocean conditions. Upon completion of testing, the final design of the Configuration I deployment equipment will be undertaken. In parallel, the preliminary fabrication and mobilization planning for Configuration I deployment will be performed. Detailed deployment equipment procurement cost estimates will also be provided.

Phase IV covers the actual fabrication, assembly and checkout of the specialized Configuration I deployment equipment. The equipment will be shipped early to Japan (tentative) for preinstallation checkout. Final GLOMAR CHALLENGER mobilization and modification procedures will be established. In addition, the deployment operational procedures will be finalized in conjunction with the DSDP Project Office. At this time, the final safety reviews will also be presented.

The actual shipboard installation of equipment and the deployment of the MSS from the GLOMAR CHALLENGER will then be undertaken. The entire operational segment should be accomplished within a two-month period including demobilization. A Configuration I deployment program report should be issued within three months after actual demonstration.

The design for the Configuration II deployment equipment will be undertaken in Phase IV. The possibility of a simplified reentry demonstration during the June-July 1982 operations will be assessed and undertaken if practical. A preliminary Configuration II mobilization plan will be issued.

During Phase V, the procurement of equipment for deployment of the Configuration II MSS from a special surface support vessel will be accomplished. A reentry fly-in-package will be fabricated and tested preparatory for final mobilization. In addition, handling equipment such as EM winches, lowering winches, and constant tensioning

equipment will need to be provided. The special surface support vessel will need to be considerably modified to handle the keelhauling, lowering, positioning, and reentry equipment, plus deployment of mooring system and communication equipment activities.

6.2 SHORE DEVELOPMENT TESTING

6.2.1 General

The specified MSS deployment equipment and plans for shore testing are discussed in the following paragraphs. More detailed test requirement specifications can be found in Appendix H. Some of these tests have been temporarily deleted from the Phase III Contract.

6.2.2 At-Sea-Test Reentry Sub Functional and Impact Test

In late 1980, it is planned that a full-scale reentry functional and impact test will be performed on one of two reentry subs. A simulated BIP will be utilized. The functional tests will demonstrate mounting, centering and lowering capabilities of the reentry sub. Drop tests on an inclined plate will also be performed in order to ascertain shock levels.

6.2.3 Cement Tests

One of the requirements for the June 1982 deployment will be that the BIP be firmly coupled to the basalt by cement. In order to do this, GMDI developed the concept of filling the borehole with a special slow cure cement prior to lowering the BIP into the borehole. This requires that the cement maintain a fluid/jell state for a minimum of 42 hours until the BIP has been lowered into the borehole. In Phase I, some preliminary laboratory tests were conducted to establish the basic formulation of a slow cure cement. It was determined from these preliminary tests that the following cement mix would provide approximately 96 hours of fluid/jell time.

- API Class G Cement

- o 12% Bentaite (Jell)
- o 1-1/4% Retarder (HR-7)
- o 1-1/4% Dispersant (CFR-2)

During the shore tests, GMDI would conduct further lab tests to insure that proper formulation is obtained. The tests involved will be as follows:

- o Effect of varying proportions of retarder, dispersant, and jell on fluid/jell time, viscosity and compressive strength.
- o Effect of temperature on fluid/jell time, viscosity and compressive strength.
- o Effect of pressure on fluid/jell time, viscosity and compressive strength.
- o Expansion properties of cement during curing.
- o Corrosion properties of cement.
- o Other tests as deemed necessary.

The above tests can all be performed in existing laboratory facilities on small samples.

6.2.4 BIP Cement Installation Tests

Following the lab tests, full-scale tests will be conducted to insure that the BIP can be lowered into the borehole full of cement prior to its curing. This test shall involve using a 254 millimeters (10 inch) diameter casing approximately 15 meters (50 ft) long and filling it with the slow cure cement. A dummy BIP shall be lowered at various intervals of time and the lowering velocity under free fall conditions established. The gross effects of the cement setting up around the BIP will be determined. In particular, the degree of bonding plus extent of voids and cracking will be explored. Also the longer term final curing properties will be established.

6.2.5 Configuration I Reentry Sub Demonstration

The second generation Configuration I reentry sub with associated BIP will be functionally and impact tested. These tests will be similar to those performed for the At-Sea-Test hardware.

SECTION 7.0 - MSS DEPLOYMENT PROGRAM COST EVALUATION

The overall MSS deployment program has been recosted in accordance with the presently defined baseline configuration. The costs are broken down by phases and by major activity.

7.1 COST PROJECTION

A preliminary cost estimate for the overall MSS Deployment Program has been prepared and is presented in Table 7.1. The baseline concept, presented in Section 3.0, forms the basis of these deployment equipment cost projections. The logistic support and mobilization costs are based upon similar field operations conducted by GMDI on other programs. The technical support projections (i.e., engineering, quality assurance, inspection, documentation, safety reviews, etc.) are consistent with a commercial type contract but are minimal for a typical government contract.

The cost summary has been organized into a matrix presentation to show costs by phase and by major activity. The Phase III costs are derived from the revised Phase III proposal (Reference 3, Section 12) recently submitted to NORDA. Appendix G provides backup data for the Phase IV activities and specific procurement costs.

Cost estimates for the March 1981 At-Sea-Test reentry demonstration are presented in Table 7.2. The cost estimate for the baseline test concept, utilizing the pipe string, is based upon the approved At-Sea-Test Plan.

Rough Order of Magnitude (ROM) costs for the June-July 1982 Configuration I deployment are presented in Table 7.3. The full definition of objective and scope for the Configuration I deployment must await the planning task to be accomplished in the follow-on Phase III activity. It is also desirable that an alternate test fly-in-package deployment be verified at the same time.

TABLE 7.1

MSS DEPLOYMENT PROGRAM COST PROJECTION

	PHASE					
	I	II	III**	IV	V*	
	Jan-Jun 1980	Jun-Sept 1980	Oct-Sept 1981	Oct-Sept 1982	Oct-Sept 1982	TOTAL
Engineering	59,000	106,800	44,570	286,000	--	496,370
Testing	--	14,500	1,149,050	261,300	--	1,424,850
Planning	15,400	21,800	88,520	77,300	--	203,020
Program Management	11,200	38,400	130,240	148,500	--	328,340
Deployment (Config. I) (Procure & Oper.)	--	--	--	1,874,500	--	1,874,500
TOTALS	85,600	181,500	1,412,380	2,647,600	--	4,327,080

*Configuration II deployment objectives and requirements have not been defined.

**Phase III Costs include development and qualification tests.

TABLE 7.2

AT-SEA-TEST DEMONSTRATION

At-Sea Test Equipment Design	$155,600
At-Sea-Test Equipment Procurement	351,230
At-Sea-Test Planning	21,800
At-Sea-Test Integration	86,400
At-Sea-Test Mobilization and Operations	360,500
Shore Testing	79,760
Evaluation	38,380
TOTAL	$1,093,670

NOTE: 1. Does not include any GLOMAR GLOMAR CHALLENGER costs.

2. At-Sea-Tests Responsibilities not fully defined.

TABLE 7.3

CONFIGURATION I DEPLOYMENT SYSTEM

PROCUREMENT AND LOGISTIC COSTS

(2 Boreholes - 1 BIP Reentry)	
Procurement and Support Services	$1,178,200
Final Procedures	58,500
Field Site Shipment, Assembly and Checkout	161,600
Mobilization and Operation*	248,600
Demobilization*	169,900
Integration	57,700
TOTAL	$1,874,500

*Excludes Costs of GLOMAR CHALLENGER nominal day rate operations.

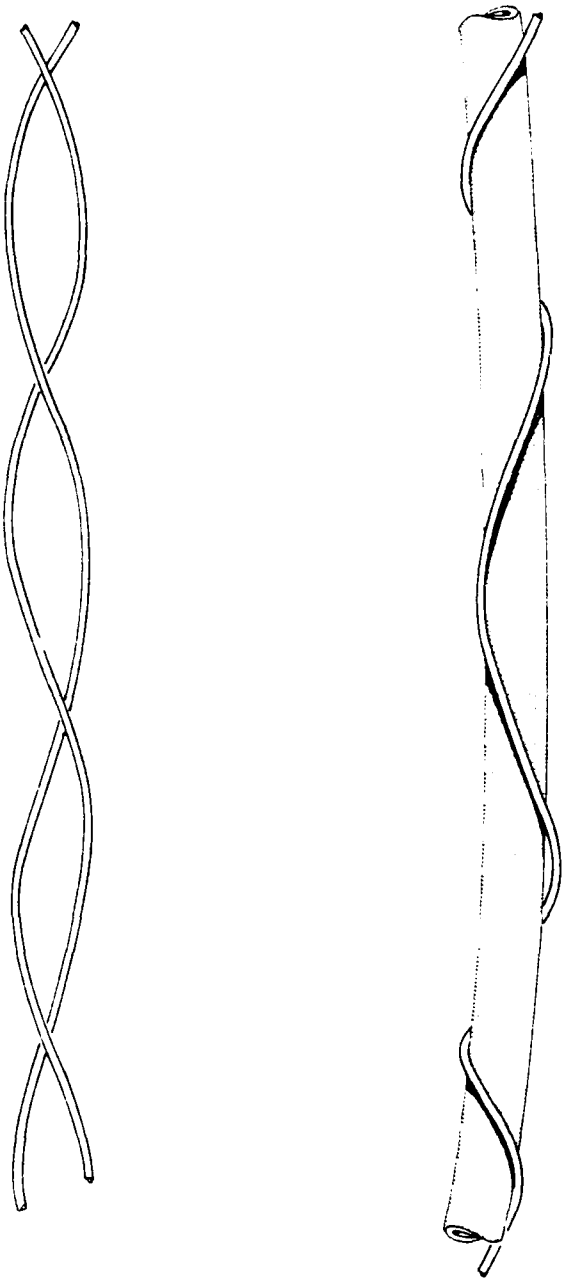
Phase V has not been costed because there has been no specific planning or criteria developed for the June-July 1983 Configuration II deployment.

SECTION 8.0 - CABLE ENTANGLEMENT EVALUATION

8.1 INTRODUCTION

The problem of deep ocean cable entanglement is unique with respect to the theoretical and environmental uncertainties that define the phenomenon. In addition most marine personnel have, at one time or another, had experience with fouled cables or lines. The theoretical analyses, indicates that the cable entanglement problem can be solved, if proper precautions are taken. However, it is the opinion of several knowledgable people, experienced in deep ocean operations that, at some time and in some manner, cable entanglement will indeed occur. For the present MSS program we have, therefore, assumed that cable entanglement continues to present a major problem for all of the BIP deployment techniques considered to date. Of all the techniques considered, the drill string reentry concept appears to offer the best solution in terms of reducing the magnitude of the problem.

An entanglement problem exists when two cables wrap and self lock around one another (Figure 8-1A) or when one cable wraps around a structural member (Figure 8-1B) such that the wrapping will not self-relieve. For the MSS deployment the probability of cable fouling as shown in Figure 8-1B is very low since the drill pipe is a very stiff, highly tensioned member and the EM Cable, although more flexible, is still relatively stiff as long as tension in the cable is maintained. Table 8.1 shows the comparative stiffness factors of the EM Cable and the drill string for various depths and tensions. The most probable form of wrapping as shown in Figure 8-1B, is termed as "D" wrap, with an open centered loop which reverses the direction of the wrapping spiral. The reversing inflection point is unstable unless a force is applied. For the sizes of cable and drill pipe considered here, the helix angle of cable with respect to the centerline of the pipe for ten wraps is much less than 1 degree and thus can usually be "pulled" free by increasing the cable tension on the cable.



A. DUAL CABLE ENTANGLEMENT

B. CABLE/PIPE WRAPPING

FIGURE 8-1 TYPICAL ENTANGLEMENT CONFIGURATIONS

TABLE 8.1

TYPICAL EM CABLE/DRILL STRING STIFFNESS PARAMETERS

	EM Cable (9/16" dia.)			DRILL STRING (5" dia.)		
	DEPLOYED LENGTH					
PARAMETER	O M	1,524 M (5,000 ft)	6,069 M (20,000 ft)	O M	1,524 M (5,000 ft)	6,096 M (20,000 ft)
AVERAGE TENSION	0	1,300 kg (580 lbs)	10,800 kg (4,900 lbs)	0	200,000 kg (92,000 lbs)	550,000 kg (250,000 lbs)
EQUIV. LATERAL. STIFF. RATIO	0.0001	10^4	10^5	1.0	10^6	10^7
LATERAL NAT. PERIOD (SECS.)	-	108	150	-	52	130
EQUIV. LONG. STIFF. RATIO	.01	.007	.006	1.0	0.93	0.85
LONG. NAT. PERIOD (SECS.)	-	1.8	7.1	-	0.6	2.5
TYP. TENSION TO MASS RATIO	-	28,000	24,000	-	87,000	230,000
TYP. TENSION TO DRAG RATIO	-	0.5	1	-	12	67

8.2 ENTANGLEMENT SUMMARY

All evaluations to date indicate that the probability of cable entanglement is quite low as long as adequate tension is maintained on the EM Cable. For the deployment technique considered, we are furthered encouraged by the fact that the EM Cable is a very highly torque balanced element which tends to prevent it from twisting. If cable entanglement does occur, disentanglement can most likely be accomplished without damage to the cable. There is little, or no, chance of damaging the drill string.

As a back-up procedure the Navy support vessel could deploy a tethered fairleader which would force the cable away from the upper segments of the drill string due to the action of the current. In the event of emergency the fairleader could be remotely released.

8.3 WRAPPING CONSIDERATION

Certain restrictive forces come into play if the EM Cable should wrap around the pipe. Various forms of potential locking mechanisms can indeed occur as shown by Figure 8-2. However, the probability of these mechanisms occuring is limited by the tension and local stiffness characteristics of the elements. Using conservative wet friction factors of approximately 0.1 the minimum number of wraps to self-lock is approximately six turns. This would require three complete 360° spiraled "D" type wraps of the cable about the pipe. There is also the possibility of the cable locking around a pipe rubber joint as shown on Figure 8-2. This would require a tension of less than 23 kg (50 lbs). Finally, the cable can be "loose" enough to wrap and self-lock between the drill pipe rubbers or tool joints or "loop" itself around the end of the pipe. A more definitive report on cable entanglement has been included in Appendix I.

In any case, a minimum tension must be maintained such that the cable cannot "kink" and/or "tie-a-knot" with itself. A cable tension of at least 45 kilograms (100 lbs) should be adequate to preclude "kinking" or "knotting" due to dynamic oscillatory motions.

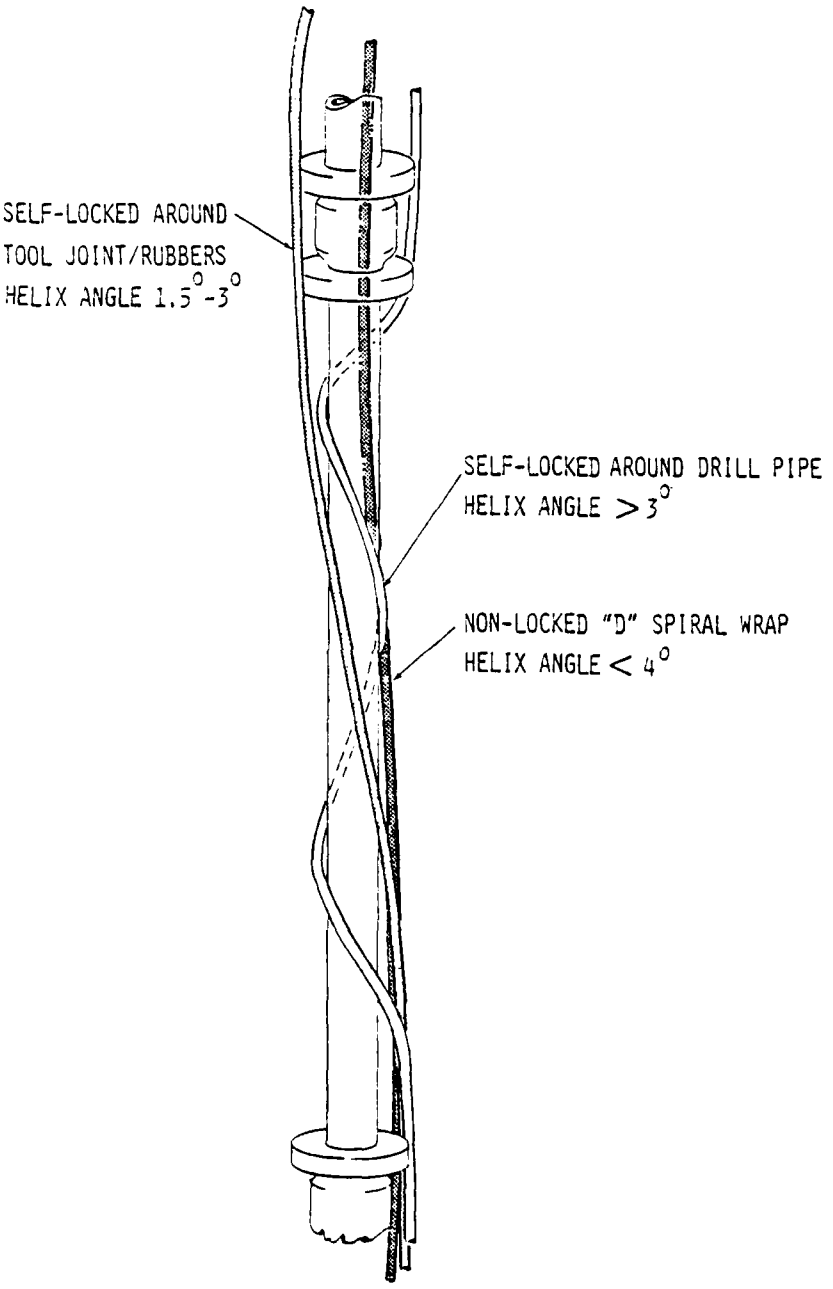


FIGURE 3-2. CABLE/PIPE WRAPPING FORMS

Wrapping can be caused by:

- o Variable flow shear currents oriented to progressively wrap one cable around the pipe.
- o Dynamic motions causing a momentary wrapping.
- o Unbalanced torsioned forces caused by varying cable tension.
- o Combination of the above.

It is hard to visualize a static current that would wrap the cable around the pipe. However it is noted that the most severe currents and dynamic displacement of the cable will take place near the upper portion of the deployed pipe string. Lower currents which exist near the seabed will only result in a partial wrap of the cable around the pipe.

The oscillatory motion of the pipe might also contribute to initial cable/pipe wrapping. More likely, this dynamic motion will tend to help "break" the wrap and disentangle the cable.

8.4 TENSIONING CHARACTERISTICS

Of prime importance in the assessment of cable entanglement is the role of cable tension, whether imposed by external forces or by the weight of the cable itself. Cable tension improves the "effective" stiffening of the cable and reduces the number of resonant modes, the relative motion of these modes, and the catenary like displacement caused by currents. For the EM Cable to be utilized for the At-Sea-Test we are limited to normal static loads of 4,540 kg (10,000 lbs) and maximum loads of 7,260 kg (16,000 lbs). The minimum tension during deployment will be maintained above 227 kg (500 lbs).

8.5 METHOD OF CONTROL

It is planned that for the baseline MSS deployment, the following controls will be simultaneously exercised:

- o Use torque balanced cable.

- o Maintain a minimum tension of at least 227 kg (500 lbs) in the cable.
- o Provide greatest separation possible near surface where the potential for wrapping is greatest.
- o Define current profile vs depth for each site.
- o Orient GLOMAR CHALLENGER in most favorable attitude, weather permitting.

All of the above precautions will contribute to reducing the probability of entanglement. The most important of these is tension control.

8.6 CABLE DISENTANGLEMENT

The remote possibility of entanglement does exist and thus procedures must be developed to disentangle the cable should wrapping occur. If entanglement occurs either the BIP cannot be lowered into the borehole or the EM Cable will not separate from the drill pipe during its retrieval. Neither case is catastrophic and no real damage to either cable or pipe string is foreseen. In the worst case a slow recovery of the drill string with the cable still attached is anticipated. A set of detailed procedures will be prepared for this contingency. Basically, these procedures will result in a plan for lifting and rotating the drill string so the cable can be unwound as the drill string is being withdrawn. A major desire is to provide direct visual coverage underneath the moonpool area and to determine the relative direction of rotation of reentry sub. Additional equipment to provide the above capabilities may be justified, particularly for later MSS deployment.

8.7 ALTERNATIVE APPROACHES

Throughout the MSS deployment program/study alternative solutions to the cable entanglement problem have been investigated. Four alternative approaches have been specifically addressed:

- o Tie-On

- o Second Vessel
- o Subsea Reel
- o Subsea Terminal Connection

The tie-on approach appears to be the most obvious solution because of its apparent simplicity. However, upon further assessment there is a distinct possibility of cable damage within the GLOMAR CHALLENGER horn plus the problem of controlled release of the ties. Most certainly the installation of several hundred ties will significantly slow down the deployment of the drill pipe string. Several types of line, tape, fabricated tie-ons have been considered, which either grab the cable or merely fairlead the cable. The use of dissolvable tie-ons was considered to solve the specific problem of removal of the ties as the drill string is retrieved.

The use of a second support vessels is potentially viable. During the early concept studies, the use of a dual vessel was investigated in which either the EM Cable winch or an EM Cable sheave installed was investigated. Both of these approaches involve stationkeeping, control and coordination problems particularly over long periods of time. Any failure could potentially be catastrophic to the cable. A more recent concept envisions utilizing the second vessel to deploy a winch controlled, running fairleader and essentially forcing the cable into an advantageously shaped catenary which directs it away from the drill string (Figure 8-3). Any failures can be accommodated by releasing the fairlead on returning the cable to the original baseline configuration. The running fairlead would incorporate a "Go-Devil" or acoustic release mechanism. Further analyses of this approach are underway preparatory to formalizing a back-up plan.

The use of a subsea EM Cable reel has also been evaluated. Potentially this approach resolves the cable entanglement problem but a subsea reel would have to be developed and extensive surface handling equipment would be required. The reentry package would have to be considerably larger to accommodate the subsea reel and associated control equipment. This approach should be more fully investigated before any future operational program is undertaken.

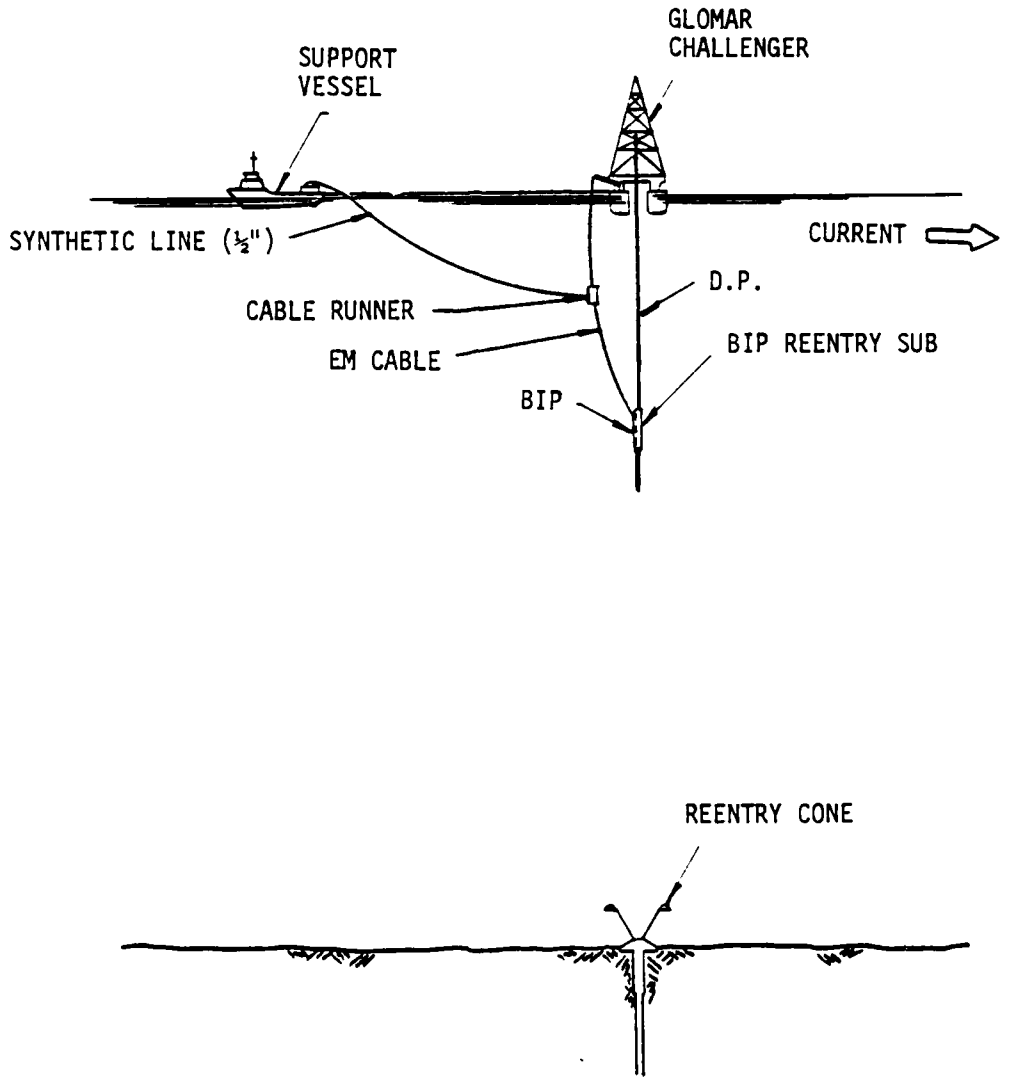


FIGURE 8-3. CONCEPT OF ELIMINATING CABLE ENTANGLEMENT PROBLEM

Finally, the possibility of running the EM Cable inside the pipe string has been explored (Reference 3, Section 12). The operational problem of tripping up to 50,000 feet of cable into, and out of, the made up drill string is extremely difficult and particular care must be exercised to avoid damage. The alternative use of a downhole EM Cable/BIP termination is remotely feasible but would require a rather major development to provide a 6,096 meter (20,000 foot), 5-year reliable life capability.

SECTION 9.0 - DRILL STRING EVALUATION

A continuing analysis of the GLOMAR CHALLENGER drill string static and dynamic displacements and stress conditions has been conducted to provide a better understanding of the response characteristics of the drill string and to define operational limits. Necessarily, this specific analytical work must be correlated with the DSDP analyses and actual operational experience. An early, and very preliminary assessment, performed during Phase I and reported in Reference 3, indicated a possibility that marginal conditions may exist when working at 6,096 meter (20,000 feet) depths under severe weather conditions.

The Phase II analysis investigated in more detail the various static and dynamic loading conditions. A variety of computer programs and analytical models were used assuming a 2 knot surface current decreasing to 0 knots at depth. The analyses and results are presented in Appendix F.

Results of the Phase II analysis are summarized below:

- Maximum displacement of the lower end of the drill pipe (DP) during installation due to current is 350 meters (1,150 ft).
- Displacement of the lower end of the DP due to current for the completely deployed pipe is 194 meters (637 ft).
- The deflected shape of the DP in the current strongly depends on the ship's offset.
- Dead weight and current both cause bending stresses in the drill pipe. Maximum values of this stress occur at the top end of the drill pipe and can be expected in the range of 4,416 kPa (640 psi) to 373,000 kPa (54,000 psi) depending on the deployed length of the DP.
- Bending stress due to current is small compared with axial stress due to dead weight. Its contribution decreases when the length of the DP is increased during installation.
- The previous conclusion confirms the assumption that the DP bending resistance is negligibly small. In other words, the drill pipe behaves like a string.

- o Maximum static bending stress does not exceed 373,000 kPa (54,000 psi).
- o Range of the natural frequencies of the DP in lateral oscillation is between 0.05 and 1.9 sec^{-1} for the first 7 modes. It corresponds to the natural periods in the range of 3.3 to 125.6 sec.
- o Ship sway motion for beam seas is the determining factor of dynamic excitation applied to the drill pipe.
- o Maximum RMS of deflection due to ship sway motion depends upon sea state condition and installed length of the DP.
- o RMS bending stress due to ship sway motion depends on the same factors (sea state condition and length of the DP). It does not exceed 23,000 kPa (3,336 psi) for 4.9 meter (16 ft) significant wave.
- o In case of no heave compensators ship heave motion does not cause excessive dynamic stresses in the drill pipe for conditions studied.
- o Combined RMS and static bending stress does not exceed 396,000 kPa (57,370 psi). Combined significant and static bending stress is not more than 419,000 kPa (60,700 psi).
- o Combined stresses in the drill pipe due to all sources of loading for any stage of the installation are less than the allowable stresses.
- o As far as the strength of the drill pipe is concerned, the installation of the reentry sub can be performed practically without restrictions for sea state conditions (of 4.9 meter (16 ft) significant wave height).

The stress levels appear to be within the allowable S135 drill string design levels. However, these factors must be confirmed with DSDP. In particular, the specific current profile must be evaluated for each deepwater site.

GMDI recommends that a more rigorous dynamic analysis be performed for sites approaching the 6,096 meter depth where severe weather and/or current conditions persist. This analysis would modify existing deep riser/cold water pipe computerized programs and would account for local stiffening, variable current, varying mass and dampening factors. This work would be performed in close conjunction with DSDP. DSDP is developing their own programs.

SECTION 10.0 - EVALUATION OF ALTERNATE REENTRY CONCEPTS

10.1 ABSTRACT

This section of the report addresses several different approaches to the borehole reentry problem. The evaluation of alternative approaches was necessitated by the fact that for future, operational MSS deployments, the dynamically positioned drillship used in the initial test stages of the program, may not be available or, in fact, may not be desirable to use for operational deployment. For this reason a reentry approach must be developed which is generally not dependent on the surface vessel used.

The two basic alternative approaches which were investigated were first, the use of guideline type systems and secondly, a remotely controlled "fly-in" system. The use of manned and/or unmanned submersible vehicles was specifically excluded from the investigation at NORDA direction.

For the guideline approach three different options were evaluated and for the "fly-in" approach five different configurations and four possible positioning methods for each configuration were considered.

10.2 CONCLUSIONS

- The tethered cable "fly-in" type platform provides the greatest potential for success for the MSS multiborehole operational deployment.
- A wide range of "fly-in" technology is available and can be applied to the MSS deployment scheme.
- The single and dual guideline approaches are technically feasible but involve technical uncertainties which would require more extensive development to reliably resolve.
- The buoyant riser guideline concept is an intriguing approach, however; its use would have a major impact on the total five-year MSS system configuration.

- Sufficient details pertaining to future MSS deployment requirements are not presently well defined and thus a final configuration cannot be confidently selected.

10.3 ALTERNATE CONCEPT REVIEW

Early in the Phase II portion of the MSS program, GMDI initiated an evaluation of possible alternate reentry concepts. This evaluation was directed at the MSS Configuration II prototype for possible deployment in June 1983. Although specific details of the 1983 MSS equipment have not yet been identified some general requirements have been postulated. Table 10.1 summarizes these general requirements.

TABLE 10.1

REQUIREMENTS FOR ALTERNATE REENTRY CONCEPTS

o DO NOT DEPEND ON USE OF DYNAMICALLY POSITIONED DRILLSHIP
o ACCOMMODATE 9.1 METERS (30 FEET) LONG BY 203 millimeters (8 INCH) DIAMETER BIP
o LOCATE AND POSITION BIP ABOVE REENTRY CONE
o GUIDE BIP INTO REENTRY CONE
o LIMIT BIP SHOCK LOADING TO LESS THAN 10Gs
o LOWER BIP APPROXIMATELY 427 METERS (1,400 FEET) INTO BOREHOLE AT SPEEDS OF LESS THAN 20 FPM
o ACCOMMODATE UP TO 15,240 METERS (50,000 FEET) OF EM CABLE WITHOUT DAMAGE
o FUNCTION IN WATER DEPTHS OF UP TO 6,096 METERS (20,000 FEET)
o BE OPERATIONAL IN SEA STATE 5
o PROVIDE CEMENTING CAPABILITY
o PROVIDE POSSIBLE BOREHOLE INSPECTION SERVICE

Two basic reentry approaches were considered:

- The guideline approach
- The "fly-in" approach

For the guideline concept three options were evaluated:

- o Single guideline
- o Dual guideline
- o Buoyant riser

For the "fly-in" concept five options were evaluated:

- o Towed platform without thruster
- o Towed platform with thruster
- o Hovering platform with thruster and anchor
- o Hovering platform with multiple thrusters
- o Hovering platform with multiple anchors

Each of these concepts is discussed in further detail in the following paragraphs.

Concurrent with the initial part of the study, GMDI personnel visited several cognizant organizations in an attempt to better understand existing deep ocean technology applicable to the study and to determine availability of equipment which might be used for the MSS deployment. The organizations visited were:

- o Naval Ocean Systems Center (San Diego)
- o Naval Ocean Systems Center (Hawaii)
- o Hawaii Institute of Geophysics
- o Naval Civil Engineering Laboratory (Port Hueneme)
- o Superintendent of Salvage (Washington)
- o National Oceanic and Atmospheric Administration - National Ocean Survey
- o Mare Island Naval Shipyard

GMDI briefed these organizations on the deep ocean reentry concepts being considered. GMDI then solicited their opinions, judgments, comments and reactions. Discussions were held on applicable technology and experience, and what equipment was required and whether it was, or could be made, available. All of the organizations expressed interest and candidly offered advice and/or assistance. The general consensus favored the fly-in concepts as opposed to either the single or dual guideline approach. The buoyant

riser concept did, however, stimulate some unusual interest which may warrant further investigation.

10.4 GUIDELINE ALTERNATE REENTRY CONCEPTS

The following three guideline approaches were evaluated:

- o Single Guideline (Figure 10-1)
- o Dual Guideline (Figure 10-2)
- o Buoyant Riser (Figure 10-3)

10.4.1 Single Guideline

The single guideline approach was determined to be the simplest concept and possibly have the added advantage of being the least expensive. It does, however, require that during drilling of the borehole, a guideline must be attached to a special sidepost. Once attached one must be able to retrieve the guideline. Thus it must either be supported by a subsurface buoy, laid on the seafloor for retrieval using a grapple, or have an acoustically released buoy which would carry the line to the surface. The single guideline option has an inherent problem related to the tendency of the EM Cable to wrap around the guideline as the BIP is lowered. At the present time there is no positive means of preventing this entanglement. The special sidepost must have a centering arrangement to orient the BIP above and into the borehole. For the single guideline concept a major shipboard guideline tensioning system will be required. The sliding carriage structure which supports the offset BIP weight as it is lowered down to the seafloor becomes large, therefore, further complicating the design.

10.4.2 Dual Guideline

The dual guideline approach avoids the EM Cable and guideline entanglement problem by using two cables which are held apart by intermittent spacers. The two guidelines will still have a tendency to twist about each other but will not entangle together. The dual

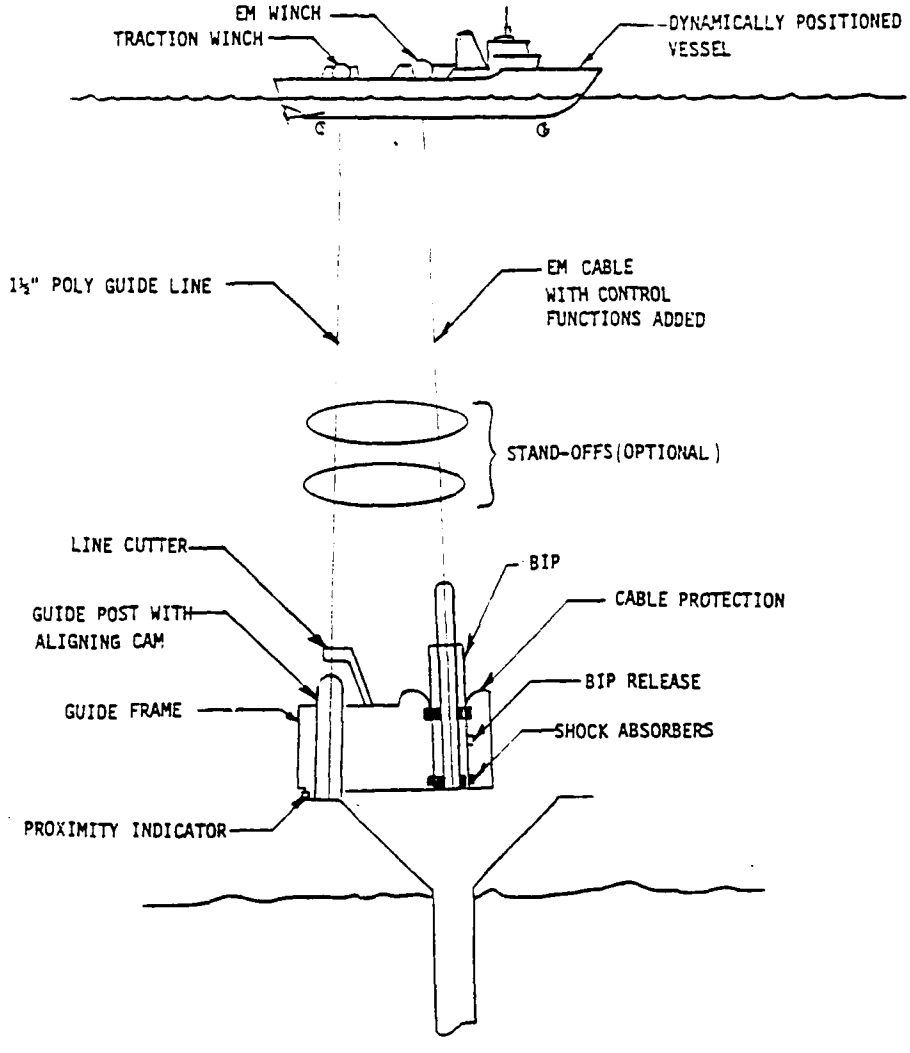


FIGURE 10-1. SINGLE GUIDELINE REENTRY CONCEPT

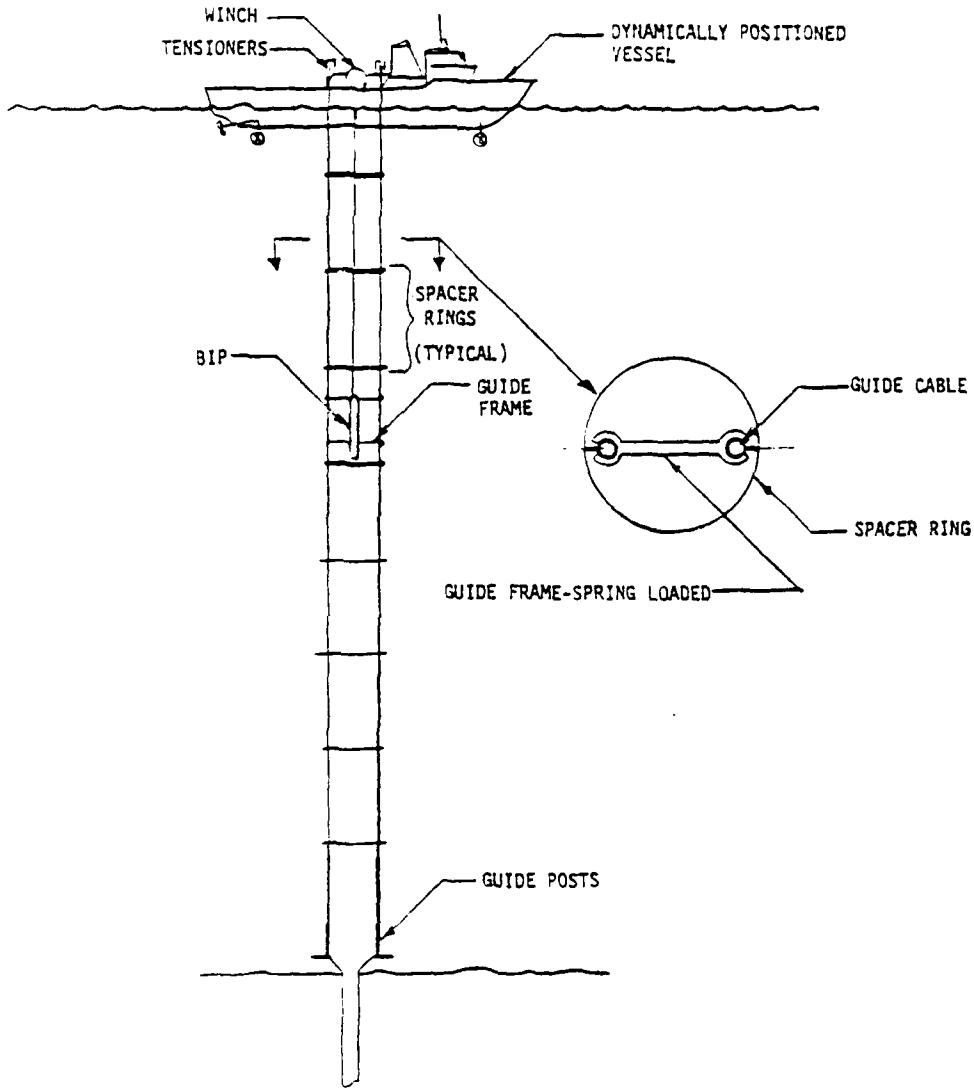


FIGURE 10-2. DUAL GUIDELINE REFERRY CONCEPT

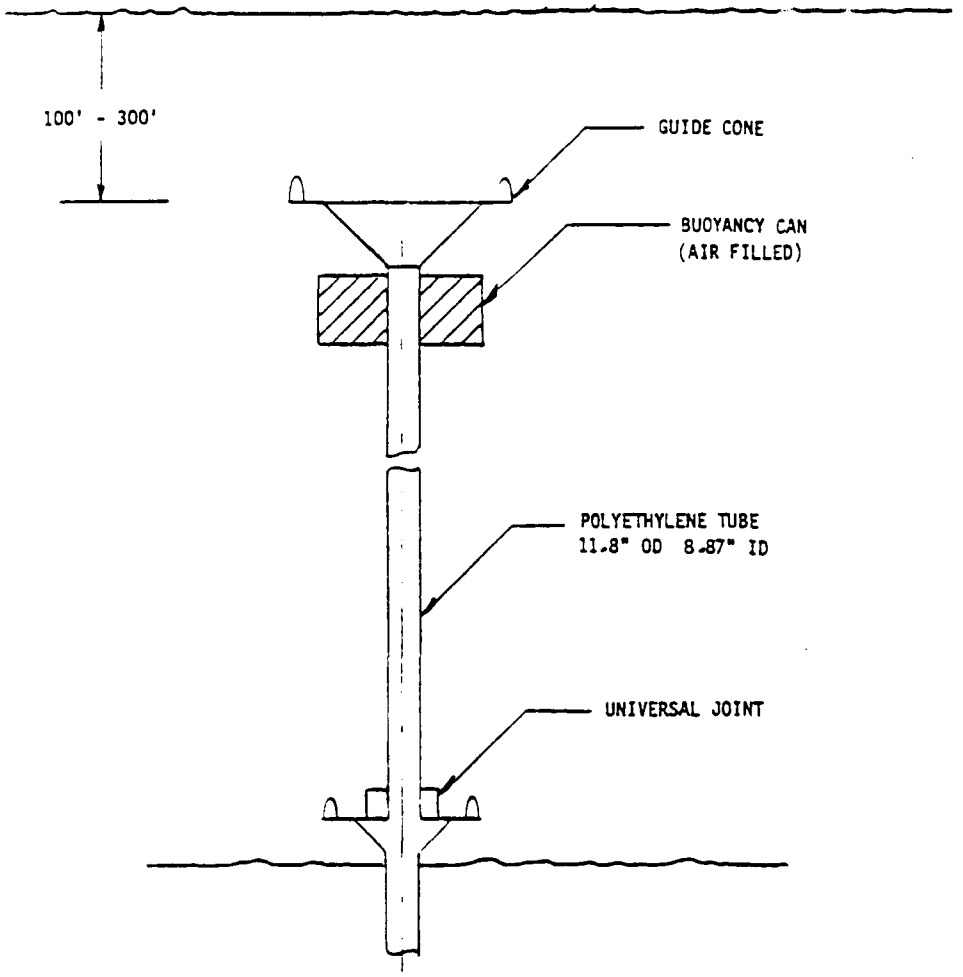


FIGURE 10-3. BUOYANT RISER

guidelines and their spacers also serve as a centering guide for the EM Cable. One disadvantage is that two cables must be deployed at the time of borehole emplacement and they must subsequently be retrieved. In addition, the cable tensioning problem is increased. The sliding carriage also becomes a quite complicated mechanism. However, all of these concerns are technically resolvable.

10.4.3 Buoyant Riser

The buoyant riser approach is a completely different technique for operational deployment. For this concept, a polyethylene or equivalent plastic fusion bonded tube is attached to the borehole casing during emplacement. The reentry problem is greatly simplified although initial borehole emplacement is considerably more difficult due to the need for handling 6,096 meters (20,000 feet) of 254 millimeter (10 inch) tubing aboard ship. To reduce this problem somewhat the tubing could be stored in 15 meter (50 foot) diameter coils on the ship. The slightly buoyant, long polyethylene tubing will assume a vertical attitude with the bottom end attached to the borehole casing through a flexible connection. Since the polyethylene is only slightly positively buoyant, by using controlled ballasting it can easily be transitioned from the vertical floating attitude to a horizontal attitude on the seafloor. If a universal joint is required at the bottom of the riser it would be similar in size and configuration to existing subsea flexible connections. Another area which must be verified is the five-year life capability when exposed to the 10,000 psi pressure environment.

The polyethylene buoyant riser concept offers an innovative approach to the MSS deployment method in that it offers some major advantages in terms of reentry capability but imposes some complex deployment requirements. Probably initial fabrication costs will be greater than for other concepts. To be cost effective, this concept would have to be fully integrated into the five-year MSS operational system by using the polyethylene tubing to protect the EM Cable and/or provide an anchored support to the MSS subsurface buoy.

Table 10.2 presents an evaluation summary of the guideline concepts considered. The dual guideline option represents the most viable option that could be developed into a workable deployment system, particularly if multiple borehole reentries are required.

The buoyant riser approach introduces many new considerations which were considered to be beyond the scope of this study. However, this concept has some merit and should be more fully explored as part of the overall evaluation of the integrated MSS system.

10.5 "FLY-IN" PLATFORM ALTERNATE REENTRY CONCEPTS

The evaluation of "fly-in" reentry concepts was somewhat more complicated due to the variety of positioning options and recovery configurations that were considered. These combinations are shown by Tables 10.3 and 10.4. The matrix of options and configurations that were assessed are shown in Table 10.4.

It should be noted that the recovery configurations are dictated by the very difficult EM Cable handling and deployment problems and therefore, will be the overriding design consideration. It has been determined that any of the selected "fly-in" options can perform the required reentry function. The choice of configuration is, however, more dependent on the specific mission requirements, surface vessel constraints and overall program cost. The following eight operations must be fully considered:

- o Launch platform at surface
- o Deploy platform until it is near the seabed
- o Position platform above borehole
- o Stab platform into reentry cone
- o Lower and set BIP
- o Retrieve platform
- o Recover platform at surface
- o Deploy EM Cable and subsurface buoys moorings

TABLE 10.2

GUIDELINE ALTERNATE CONCEPTS SUMMARY

DEMONSTRATED	4,500 FT DUAL GUIDELINE	
GENERAL CONSENSUS	o BASIC GUIDELINE CONCEPTS FEASIBLE o REQUIRES DEVELOPMENT WITH EXTENSIVE DEEP WATER TESTING o ENTANGLEMENT PROBLEMS FOR SINGLE AND DUAL CONCEPTS o GOOD FOR MULTIPLE REENTRY o BUOYANT RISER CONCEPT IS AN INNOVATIVE APPROACH THAT SHOULD BE EVALUATED	
	ADVANTAGES	DISADVANTAGES
SINGLE GUIDELINE	LEAST COST MULTIPLE REENTRY	VERY PRONE TO ENTANGLEMENT LARGE TENSIONING CAPABILITY REQUIRED BOTTOM ALIGNMENT FIXTURES NEEDED BUOYED OR RECOVERABLE GUIDELINE MUST BE PROVIDED EM CABLE MUST BE TORQUE BALANCED
DUAL GUIDELINE	MULTIPLE REENTRY REDUCED RISK OF ENTANGLEMENT	DUAL LARGE TENSIONING CAPABILITY REQUIRED BUOYED OR RECOVERABLE GUIDELINES MUST BE PROVIDED GUIDELINE TRAVELING FIXTURE COMPLICATED DESIGN
BUOYANT RISER	MULTIPLE REENTRY PROTECTION FOR EM CABLE SIMPLIFIED REENTRY NO ENTANGLEMENT PROBLEM	EXPENSIVE INITIAL COST RISER DIFFICULT TO DEPLOY POSSIBLE NOISE PROBLEM WITH EM CABLE UNIVERSAL JOINT AT BOTTOM

TABLE 10.3

FLY-IN PLATFORM ALTERNATIVES

		BASE EQUIPMENT	REENTRY MODE
1	TOWED PLATFORM	FINS FOR AZIMUTH ORIENTATION	SLOW TOW VELOCITY PLUS DP MANEUVERING
2	TOWED PLATFORM WITH SINGLE THRUSTER	FINS FOR AZIMUTH ORIENTATION PLUS PLUS FIXED REVERSIBLE THRUSTER	TOW VELOCITY PLUS DP MANEUVERING PLUS LATERAL THRUST AUGMENTATION
3	HOVERING PLATFORM WITH THRUSTER PLUS ANCHOR	VARIABLE DIRECTION THRUSTER PLUS FIXED ANCHOR	DP MANEUVERING PLUS JETTISONED ANCHOR PLUS THRUST FOR FINAL POSITIONING
4	HOVERING PLATFORM-MULTIPLE THRUSTER	FINS FOR ATTITUDE CONTROL - 4 FIXED REVERSIBLE THRUSTERS	DP MANEUVERING PLUS THRUSTER POSITIONING
5	HOVERING PLATFORM-MULTIPLE ANCHORS	ANCHORS, CABLE AND WINCHES MOUNTED ON PLATFORM	DP MANEUVERING PLUS ANCHOR PAYOUT POSITIONING
1	EXPENDABLE PACKAGE	SIMPLE STRUCTURE PACKAGE - COMPLETE FLY-IN PACKAGE ABANDONED	
2	DUAL EM CABLE/TETHER	DUAL EM CABLE/TETHER - STRIP OFF TETHER DURING PLATFORM RECOVERY	
3	JETTISONED PACKAGE	SEPARATE BALLAST AND FLOAT ELECTRONICS TO SURFACE	
4	EM CABLE SUBSEA PAYOUT	CARRY 9,144 METERS (30,000 FEET) OF CABLE TO BOTTOM AND RELEASE DURING PLATFORM RECOVERY.	

TABLE 10.4

FLY-IN OPTION EVALUATION MATRIX

CONFIGURATION / PLATFORM OPTION	EXPENDABLE PACKAGE	DUAL EM CABLE/TETHER	JETTISONED PACKAGE	SUBSEA EM CABLE PAYOUT
Towed, without thruster	X	X	-	-
Towed, with thruster	X	X	X	-
Hovering, with thruster and anchor	X	X	X	X
Hovering, with multiple thrusters	-	X	X	X
Hovering, with multiple anchors	-	X	X	X

In addition, the potential need to pump approximately 25 cubic feet of cement must be accommodated as part of the above operations or as a completely separate operation.

10.5.1 Basic Reentry Configurations

- The Expendable Package

 The typical expendable package as shown in Figure 10-4 eliminates the EM Cable entanglement problem because it is unnecessary to retrieve the subsea deployment equipment (platform, reentry tool and logging cable).

- Dual EM Cable/Tether

 The dual EM Cable/tether design can recover the subsea deployment equipment at the risk of entanglement and with a need for complicated equipment to strip off the tether cable off the EM Cable.

- Jettisoned Package

 The jettisoned package is a compromise wherein a portion of the more expensive thruster and control equipment is separated from the platform and retrieved at, or floated to, the surface.

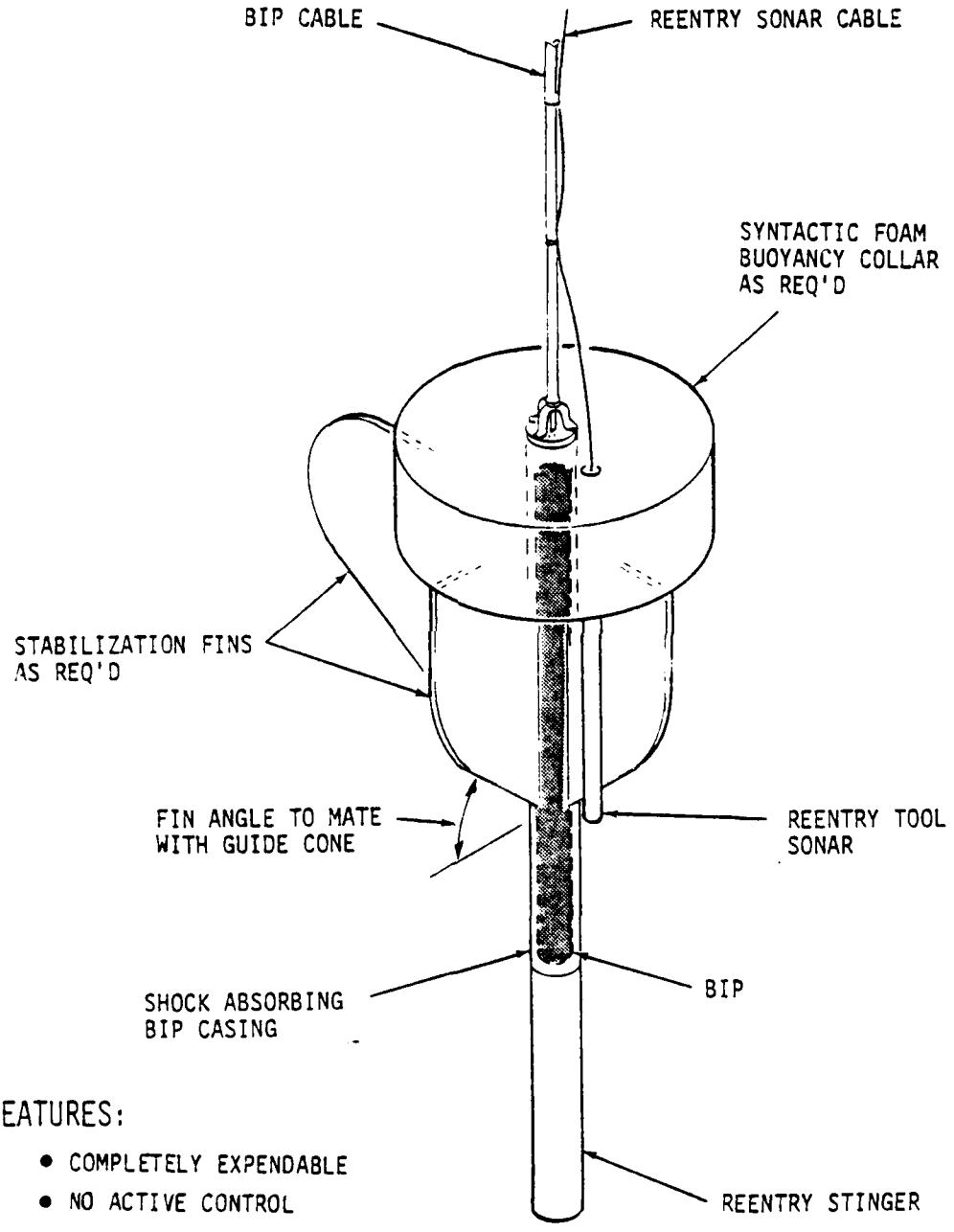
- Subsea EM Cable Payout

 This configuration concept employs a subsea cable reel mounted on the seafloor. This reel can contain as much as 6,096 meters (20,000 feet) of EM Cable approximately 25 millimeters (1 inch) in diameter. The reel can be either left with the reentry cone or retrieved using the tether. In either case, the EM Cable entanglement problem is resolved. This approach would require a large platform structure weighing approximately 16,000 kilograms (35,000 pounds).

10.5.2 Platform Options

- Towed Without Thruster

 The "towed without thruster" option shown in Figure 10-4 represents the simplest approach and can be considered for either the expendable or dual EM Cable/tether configurations. For this concept the assembly is flown-in by maneuvering the surface vessel until proper positioning is achieved. A structure with



FEATURES:

- COMPLETELY EXPENDABLE
- NO ACTIVE CONTROL

FIGURE 10-4. EXPENDABLE TOWED FLY-IN PLATFORM WITHOUT THRUSTER

stabilizing fins will be necessary to maintain azimuth orientation. Final positioning and placement would use an expendable sonar reentry tool and cable. Reentry is achieved by a quick payout of tether cable thus dropping the BIP into position. This concept represents a simple modification of existing towed vehicle techniques. The hydrodynamic shape and size of the platform must be considerably modified to adapt to a BIP. Improved reentry reliability could be achieved by using a thruster powered dynamically positioned surface ship. If the weather and current conditions are favorable, reentry can be accomplished within a reasonable time period utilizing this concept. Reentry should not be attenpted during adverse weather conditions when sea states exceed Condition 2.

- Towed With Thruster

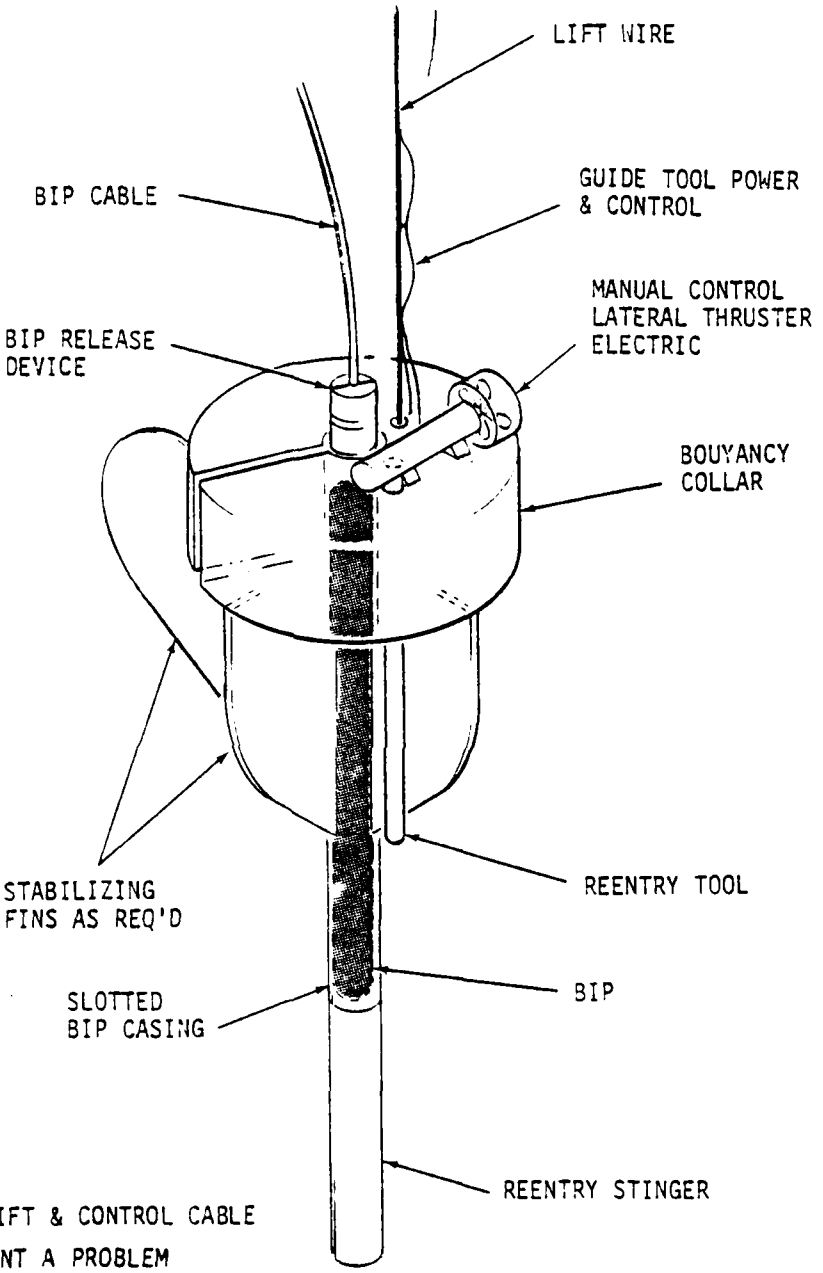
 The towed with thruster option shown in Figure 10-5 is similar to the towed configuration without a thruster but with the addition of a single, laterally directed thruster. A simple pulse type propulsion control would be utilized in conjunction with the maneuvering of the surface ship to achieve final positioning over the reentry cone. A subsea battery could also provide the limited power required. The thruster augmented system would considerably reduce the time required for positioning.

- Hovering - With Thruster and Anchor

 The hovering platform with the thruster/anchor option, has an added complication in that a variable directional thruster plus a subsea anchor and winch are required. The surface ship must position the hovering platform in the general area, i.e., 91.5 meters (300 feet) of the reentry cone where the anchor can be deployed. Final positioning would be accomplished by alternating use of the subsea winch and the thruster mounted on the BIP assembly. Both the time required for reentry and the impact forces due to reentry would be considerably reduced with only a minimum increase in system complexity and platform costs.

- Hovering - With Multiple Thruster

 The multiple thruster concept shown in Figure 10-6 represents a more sophisticated approach. Based upon conversations with several organizations (see Section 10.3) it appears that there is existing technology, experience and equipment available to



FEATURES:

- SEPARATE LIFT & CONTROL CABLE
- ENTANGLEMENT A PROBLEM
- RECOVERABLE RUNNING TOOL

FIGURE 10-5. RETRIEVABLE THRUSTER ASSISTED FLY-IN-TOOL

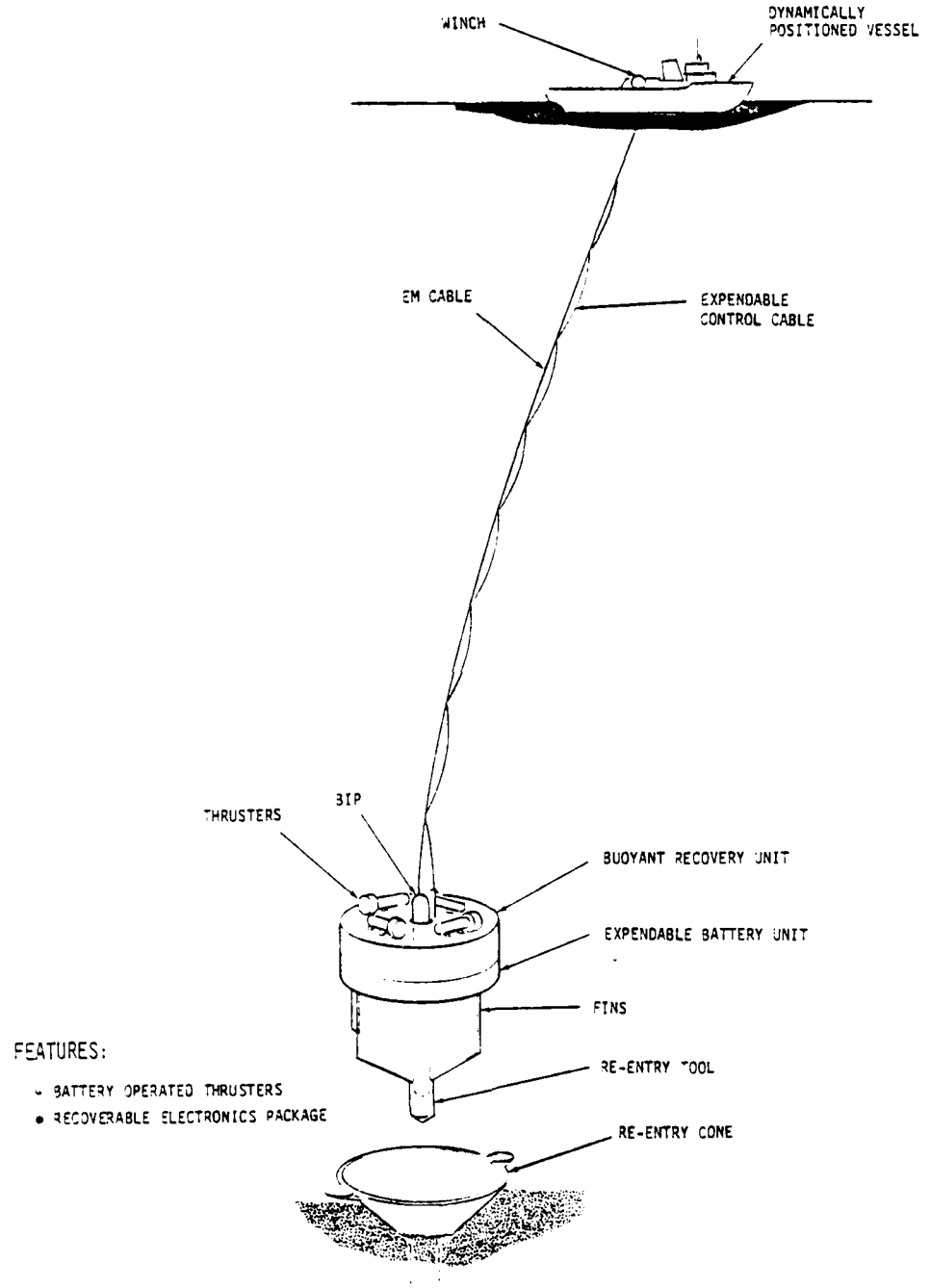


FIGURE 10-6. MULTIPLE THRUSTER CONCEPT

9913-118

support the multiple thruster concept. Positioning and azimuth control are provided by actuation of the thrusters. Regulation of the thrust can be accomplished by manual control of a joy stick or by a semiautomatic feedback control system. Power could be provided through the EM Cable. Use of the multiple thruster option would reduce the demand on the station keeping and maneuvering capabilities of the surface vessel. Although this concept presents a more flexible approach to the overall deployment scheme, the weight of the platform, hardware cost and the associated tether and EM Cable are significantly increased. Thus an expendable configuration is no longer practical although a partially jettisoned package as shown in Figure 10-7 might be justified.

- Hovering - With Multiple Anchors

 The final option substitutes three subsea anchors for the thrusters. Initial positioning of the three anchors around the reentry cone is performed by the surface ship. Final positioning is provided by payout and/or haul-in of cables mounted on winches installed for this purpose. The control is ON-OFF, thus continuous power would not be required. Relatively precise control of reentry positioning is provided using this method. Development of a short-lived, 6,096 meters (20,000 foot) depth capability, geared, electrically powered, subsea winch is not expected to be difficult although the obvious problems of seals, electrical terminations, connector, and lubrication would have to be addressed. The multiple winch option easily provides the capability to handle the large platform size associated with a subsea EM Cable reel and/or cement bucket. The major problem with multiple anchors appears to be the operational deployment of three anchors within an area of approximately 93 square meters (1,000 sq. ft.) without entangling the anchor cables.

10.5.3 Ultimate Concept

The ultimate configuration is shown in Figure 10-8. In this design, the cementing and BIP reentries are combined. To avoid cable entanglement, the EM Cable reel is made as an integral part of the subsea package and is either left on the seafloor at the borehole or

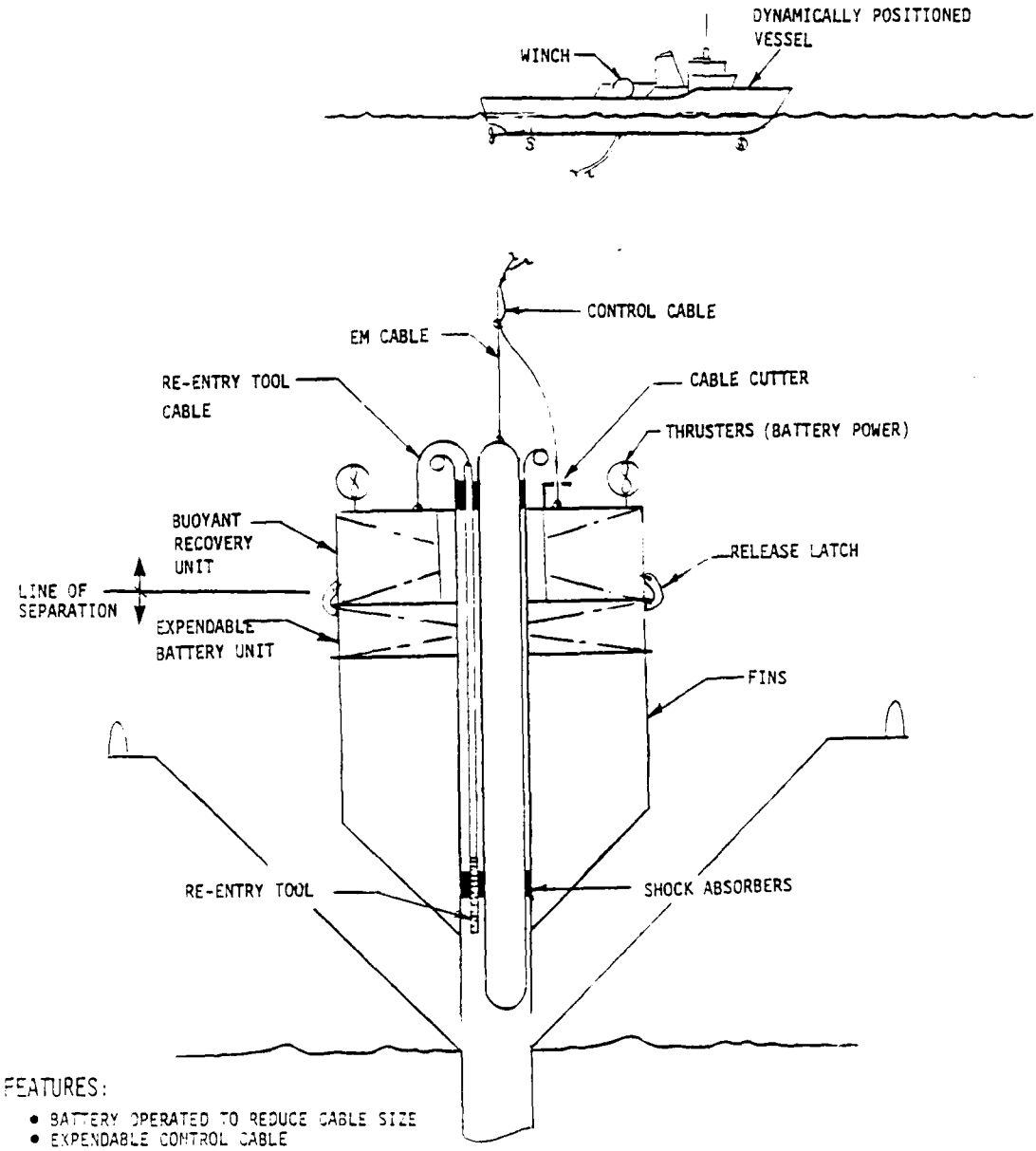
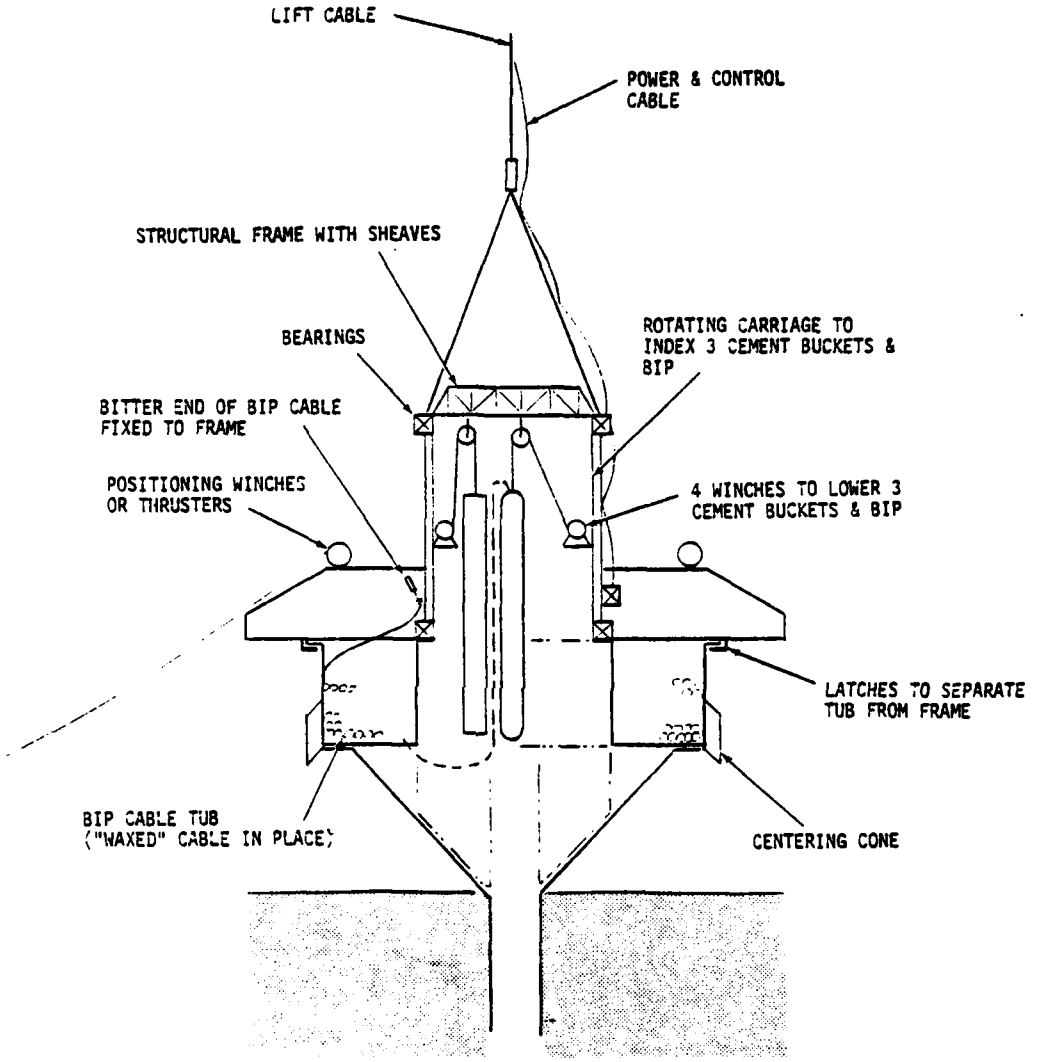


FIGURE 10-7. MULTIPLE THRUSTERS WITH PARTIALLY JETTISONED CONTROL PACKAGE



FEATURES:

- CEMENT BUCKETS & BIP LANDED IN ONE OPERATION
- BIP CABLE ENTANGLEMENT ELEMINATED
- CABLE TUB REMAINS ON BOTTOM
- HEAVY
- COMPLEX

FIGURE 10-3. RECOMMENDED CONFIGURATION

9913-115

can be recovered with the platform. Thus the BIP is first lowered into the borehole and then the EM Cable is payed out during recovery. Either a multiple thruster or multiple subsea anchor winch positioning capability could be utilized. Table 10.5 compares equipment requirements for both positioning configurations used in the recommended approach. This platform would be very large and would require extensive handling equipment onboard the surface ship and possibly require a moonpool or center well.

10.5.4 SUMMARY

A summary of the fly-in platform evaluation is presented in Table 10.6. As was discussed in Paragraph 10.5.3 and as noted on Table 10.6 it is GMDI's recommendation that further MSS alternate reentry concepts concentrate on a fly-in platform with combined BIP and cementing reentry capability. The various options and configurations which have been discussed should be compared on the basis of specific operational requirements. The major areas which require further definition are:

- Influence of static/dynamic current conditions on fly-in platform lateral/vertical track.
- Directional stability of fly-in package with fin(s).
- The effect of ship motion characteristics on fly-in package dynamics.
- Thruster effectiveness with and without proportional control.
- Retrieval of fly-in platform after reentry.
- How to avoid entanglement of EM Cable and tether.
- Determination of stabbing reentry velocity and resultant impact forces.
- Adaptation of available thruster system (thruster, power, control equipment).
- Reentry cone design to improve fly-in reentry techniques.
- Tether cable dynamics.
- Demonstration of surface ship dynamic positioning requirements.
- Development of deep ocean subsea anchor winches.

TABLE 10.5

COMPARISON OF FLY-IN PACKAGE EQUIPMENT

MULTI-ANCHOR	MULTI-THRUSTER
FLY-IN PACKAGE STRUCTURE	FLY-IN PACKAGE STRUCTURE
REENTRY TOOL (SONAR/TV) RANGE AZIMUTH ALTITUDE	REENTRY TOOL (SONAR/TV) RANGE AZIMUTH ALTITUDE
REENTRY EM CABLE STRENGTH MEMBER REENTRY TOOL SIGNALS POSITION TRANSPONDER 3-ANCHOR POWER CABLES 3-ANCHOR PAYOUT LENGTHS INDICATOR 3-ANCHOR TENSION INDICATOR	REENTRY EM CABLE STRENGTH MEMBER REENTRY TOOL SIGNALS POSITION TRANSPONDER 4-THRUSTER POWER CABLES GYRO COMPASS INDICATOR
3-SUBMERGED ANCHOR WINCHES ON-OFF WINCH CONTROL MULTIPLEXER 9,144 METER (30,000 FOOT) BIP POSSIBLE EM CABLE AND REEL BUOYANCY PACK SURFACE CONTROL CONSOLE	4-THRUSTERS AUTO THRUSTER PROPORTIONAL CONTROL MULTIPLEXER 9,144 METER (30,000 FOOT) BIP POSSIBLE EM CABLE AND REEL BUOYANCY PACK STABILIZATION FINS SURFACE CONTROL CONSOLE

TABLE 10.6

SUMMARY OF ALTERNATE FLY-IN PLATFORM EVALUATION

TECHNOLOGY ASSESSMENT

- SEVERAL DEEP OCEAN TOWED VEHICLES, BOTH COMMERCIAL AND NAVY, HAVE ALREADY BEEN IN OPERATION.
- TOWED VEHICLES HAVE MAINTAINED HOVER OVER A TARGET IN VERY DEEP WATER.
- EQUIPMENT FOR DEEP OCEAN MULTIPLE THRUSTER SYSTEMS IS AVAILABLE BUT WILL REQUIRE ADAPTATION FOR MSS.
- THERE IS LIMITED DEEP OCEAN EXPERIENCE USING THRUSTER CONTROL FOR POSITIONING.
- THERE IS NO DEEP OCEAN EXPERIENCE WITH MULTIPLE ANCHORS.

GENERAL CONSENSUS

- FLY-IN-APPROACH USING THRUSTERS IS FEASIBLE WITHIN DESIRED TIME SPAN.
- THRUSTER AND CONTROL EQUIPMENT MUST BE KEPT SIMPLE.
- THRUSTER MAY REQUIRE ONLY A SIMPLE PULSE AUGMENTATION.
- ANCHORED CONCEPT APPEARS PROMISING BUT THERE IS UNCERTAINTY CONCERNING SUBSEA WINCHES AND OPERATIONAL TECHNIQUES.

SECTION 11.0 - GLOSSARY

DARPA	Defense Advanced Research Projects Agency
NORDA	Naval Ocean Research & Development Agency, NSTL, Mississippi
GEOTECH	Geotech Teledyne, Dallas, Texas
GOULD	Gould Chesapeake Instrument Division, Glen Burnie, Maryland
GMDI	Global Marine Development Inc., Newport Beach, California
GMDC	Global Marine Drilling Company, Houston, Texas Operator of GLOMAR GLOMAR CHALLENGER
DSDP	Deep Sea Drilling Program Project Office Scripps Institution of Oceanography
NSF	National Science Foundation
JOIDES	Joint Oceanographic Institution for Deep Earth Sampling
MSS	Marine Seismic System
CONFIG. I	Prototype Short Seismic Period MSS Configuration
CONFIG. II	Long Seismic Period MSS Configuration With 5 Year Capability
BIP	Borehole Instrumentation Package - Seismic Downhole
REENTRY SUB	Special Lower End Fixture Which Supports the BIP
REENTRY CONE	Special Cone Developed by DSDP for Drill String Reentry
REENTRY TOOL	Sonar/TV Reentry Control Subsea Sensor
BASELINE CONCEPT	Reentry Concept based upoon Lowering BIP at End of Drill String into Borehole
FLY-IN CONCEPT	Reentry Concept that flies in BIP on End of Cable into Borehole
GUIDELINE CONCEPT	Reentry Concept that Utilizes Fixed Guideline to Reenter BIP into Borehole
EM CABLE	Electromagnetic Cables - Used with BIP and Reentry Tool

SECTION 12.0 - REFERENCES

1. Gould Inc. (CID) Purchase Order No. 00650, dated May 29, 1980 (Prime ONR Contract N00014-79-C0490).

2. ONR Contract No. N00014-80-C-0821. Period of Performance June 10, 1980 through September 30, 1980.

3. GMDI Report RPT-04114-001 - "Phase I MSS Deployment Feasibility Study for Gould, CID, dated 27 June 1980

4. GMDI Proposal P050880 - "Marine Seismic System Program," dated 28 May 1980

5. GMDI Proposal P080180 - "Phase II of the Marine Seismic System Deployment Program," Rev. 5 September 1980

6. Draft Agreement NSF/DARPA, dated 9 September 1980

RPT-001-005
REV. 0
ARPA ORDER NO. 3693

MARINE SEISMIC SYSTEM DEPLOYMENT PROGRAM
PHASE II
APPENDICES

9 JANUARY 1981

APPENDIX A

MSS AT-SEA-TEST PLAN SYNOPSIS

DEPARTMENT OF THE NAVY
NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY
NSTL STATION, MISSISSIPPI 39529

IN REPLY REFER TO

Revised 12 December 1980

MARINE SEISMIC SYSTEM PROGRAM

AT-SEA-TEST PLAN SYNOPSIS

APPROVED BY: J. A. Ballard
NORDA

PREPARED BY

GLOBAL MARINE DEVELOPMENT INC.
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IRVINE, CALIFORNIA 92715

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MSS DEPLOYMENT

AT-SEA-TEST PLAN SYNOPSIS

I. OBJECTIVES

The primary objective is to provide a proof of principal demonstration for the deepwater borehole BIP concepts, specific goals are:

1) Demonstrate deepwater instrumented package deployment
2) Collect data for BIP final design
3) Demonstrate sub-seabed instrumentation effectiveness

Deepwater BIP reentry into a borehole will be demonstrated utilizing the baseline concept which lowers the BIP at the end of a drill string. Reentry impact shock levels are to be measured. Cable entanglement data will also be measured as applicable. Short period seismic data from within the existing borehole is also to be provided over a 24 hour period to confirm sub-seabed installation effectiveness. Subbottom vertical reflection survey, air gun seismic echo recording and slant range explosive testing is to be accomplished using the USS Bartlett (AGOR). Recovery of the test BIP is to be attempted.

*II. ORGANIZATION RESPONSIBILITIES

The following responsibilities are :

Program Management	NORDA
Test System Integration and Technical Coordination	GMDI

* Denotes revised areas

Support Ship	NORDA/GMDI
CHALLENGER Operations	DSDP/NSF/GMDC
Reentry Test Equipment	GMDI
BIP Test Package	GEOTECH
Reentry Data MonitoringEquipment	GMDI
EM Cable and Winch	GEOTECH
Seismic and Acceleration Data Monitoring Equipment	GEOTECH
CHALLENGER Modifications	GMDC/GMDC
Test Procedures	GMDI
Test Logistic Support in San Juan	GMDI
Current Meter Equipment	NORDA
Demobilization in Las Palmas	GMDI
MSS OBS Calibration Experiment	NORDA
USS Bartlett Operations	NORDA

III. LOCATION

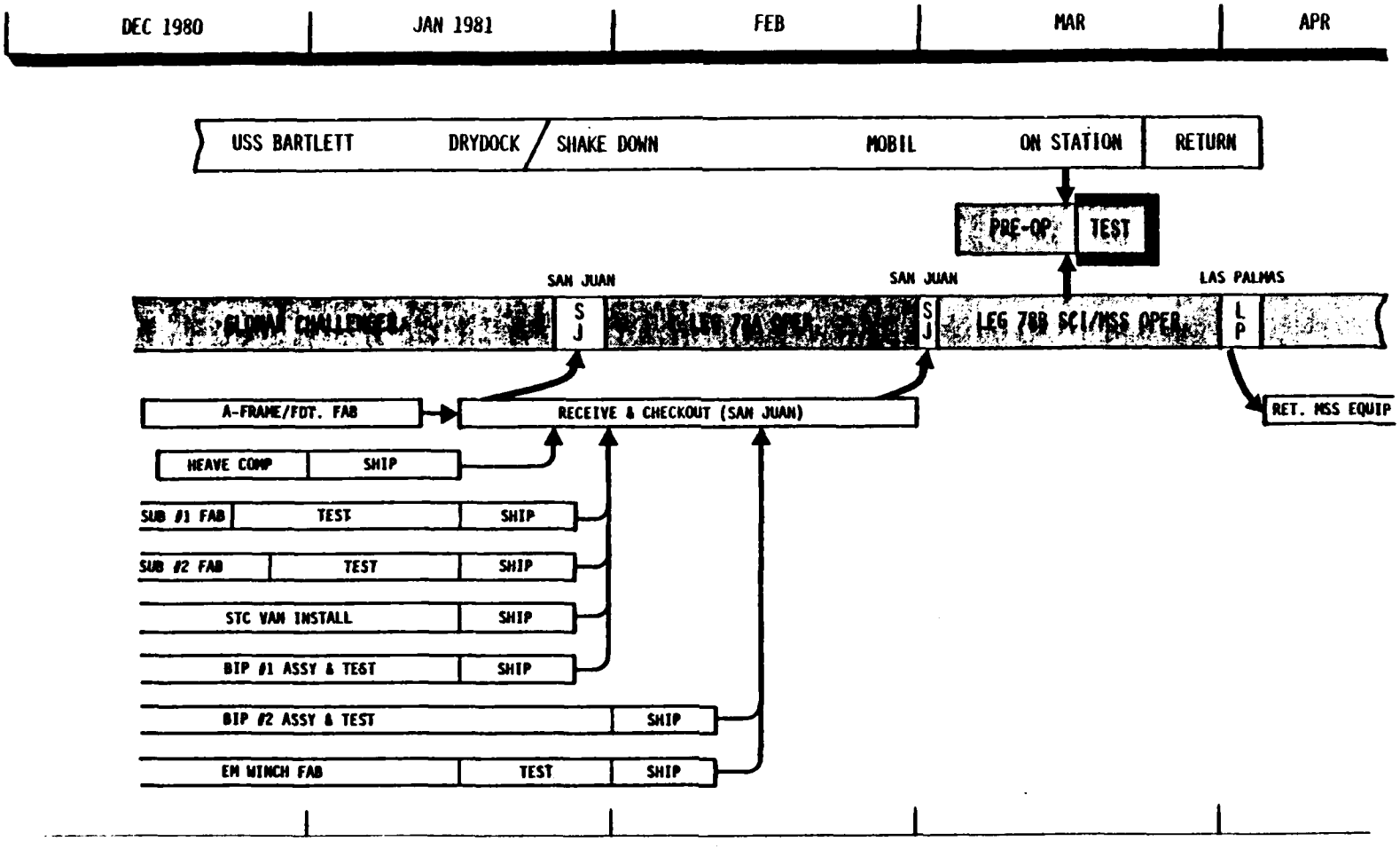
The proposed tests will tentatively be accomplished in the mid-Atlantic area utilizing an existing hole/reentry cone installed earlier by the CHALLENGER DSDP. Site 395A will be the primary hole with Site 396B as alternate. These sites are located along the 23 degree North parallel at the 46 degree West and 43-1/2 degree West Mefidians respectively.

*IV. SCHEDULE

The proposed test will tentatively take place in the early part of March 1981 during the CHALLENGER transit leg 78B to Las Palmas. Total estimated site time of CHALLENGER at-sea involvement is 6 days for the MSS Test. Fig. IV-1 depicts the current overall schedule. There is also an integrated test schedule updated bimonthly.

12 DEC 1980

SUMMARY MSS AT-SEA-TEST SCHEDULE



0006-031

Ship modifications plus installation of the foundation and cabling for test equipment will be accomplished in parallel to other regular DSDP logistic efforts in the January 23, 1981 San Juan port call. In late February 1981 the CHALLENGER will return from the Martinique area to San Juan for a 2 day final installation of the MSS equipment. Unloading in Las Palmas should take 1/2 day if full retrofit is not required. A receiving and test facility at San Juan is to be available 1 month before installation.

The USS BARTLETT will mobilize in Mayport. Jacksonville during the last week in February 1981. A special mobilization period of several days will be required to outfit a Navy vessel for support operations. The USS BARTLETT will arrive on station at the same time as the GLOMAR CHALLENGER.

*V. TEST AGENDA

The following preliminary Scientific and MSS test agenda has been tentatively established.

		Est. Time	
1.	Locate site and run in drill string	2 days	
2.	Borehole logging program	2 days	Scientific Testing
3.	Fracturing experiment	2 days ***	
4.	Oblique seismic and magnetometer testing	2 days ***	
5.	Multiple reentry demonstration baseline concept	1-1/2 days	
6.	Lower BIP into borehole and record data	1-1/2 days	MSS Testing
7.	Recovery Test BIP	1/2 days	
**8.	Weather and malfunction contingency	2-1/2 days	

Some of the listed scientific tests denoted by triple astericks may not be performed.

** Installation of cement plug and subsequent drill out has been deleted.

*VI. EQUIPMENT REQUIREMENTS

The following At-Sea-Test equipment has been defined for the baseline system.

1) BIP Lowered at End of Pipe (Baseline)	Responsibility	Remarks
BIP reentry test package	GEOTECH	
EM Cable	GEOTECH	NORDA supplied
Reentry tool (sonar) and readout console	-	Onboard
Reentry sub (15,000 ft. depth) includes impact stinger, release mechanism, reentry tool support and control manifold	GMDI	
BIP recording console van (STC)	GEOTECH	
Reentry tool winch and cable	_	Onboard Schlumberger Winch/Cable
BIP EM Cable Winch	GEOTECH	Navy spec.
A-Frame including foundations	GMDI	
Cable tension and measurement equipment	GMDI	
Reentry Cone	-	Use existing cone
Miscellaneous handling equipment	GMDI	
Deployable current meter (3000 ft)	NORDA	
Bottom current meter (reliable)	NORDA	
OBS Seismic Packages (4)	NORDA	
ASK Beacons	DSDP	
A-Frame Heave Compensator	GMDI	
Sub surface TV system	GMDI	

VII. TEST DATA OBJECTIVES

1) Reentry Demonstration

Reentry sub velocity (lateral)

Reentry sub position relative to ship and reentry cone

Ship stationkeeping characteristics

Shock impact

Current profile with depth

Cable tension

Reentry stabbing velocity

2) Lowering Demonstration

BIP lowering velocity

Surface cable payout

Lowering cable tension

3) Seismic in Hole Demonstration (24 Hours Real Time)

Short period seismic data 3 vertical channels/sensor - 2 sensors

OBS comparative data

Noise of ship affect

BIP State of Health Instrumentation - 4 temperature

1 pressure

2 short circuits

6 voltage

*VIII. SPECIAL CONSIDERATIONS

1) The use of the high strength drill string is an expensive and long lead procurement item. Present responsibility for the drill string lies with DSDP

2) Both 395A and 396B boreholes are filled with mud which must be flushed out and replaced with light gel.

3) Cementing the BIP into the borehole is not included.

4) A spare test BIP and reentry sub will be provided.

5) Special training for operation of the EM cable winch must be provided for 2 GMDC personnel.

6) The shipping facilities to San Juan are limited.

*IX TEST PERSONNEL

Accommodations for At-Sea-Test personnel will be as follows:

NORDA	1
GMDI	3
GEOTECH	3
DARPA	1
	8

APPENDIX B

AT-SEA-TEST BASE LINE DEPLOYMENT SYSTEM REQUIREMENTS SPECIFICATION

SPC-001-001

MARINE SEISMIC SYSTEM PROGRAM

AT-SEA-TEST

BASELINE DEPLOYMENT SYSTEM INTERFACE & REQUIREMENTS SPECIFICATION

(JOB 00006-325000)

REVISION 4

12 DEC 1980

Approved _____
GMDI

PREPARED BY

GLOBAL MARINE DEVELOPMENT INC.
2302 MARTIN STREET
IRVINE, CALIFORNIA 92715

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AT-SEA-TEST BASE LINE DEPLOYMENT SYSTEM REQUIREMENTS SPECIFICATION

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DOCUMENT NO. SPC-001-001

GLOBAL MARINE DEVELOPMENT INC.

Newport Beach, Calif.

REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
A	16 Aug 80	R. Wallerstedt	Preliminary Release for NORDA Review	ALL
1	05 Sep 80	R. Wallerstedt	2.0 Revised References	1
			4.2 Added Note About Filled in Borehole	2
			4.7 Added New Operational Criteria	3
			5.2 Deleted 10 days of Remotely Recorded Seismic Data	5
			6.1 Revised BIP Configuration Dimensions	5
			6.2 Revised Weight of BIP	5
			6.5 Deleted Magnetic Azimuth	7
			6.6 Deleted Magnetic Azimuth	7
			6.8 Reduced Mag. Tape Capability to 5 days	8
			6.9 Added EM Cable Design Data	8
			7.1.5 Deleted Optional Mechanical Actuation	10
			7.1.6 Reduced Lowering Speed to 20 ft./min.	10
			7.4 Deleted Lowering Cable Requirement	12
			8.2 Deleted Reentry Tool Console	12
			8.5 Deleted Lowering Cable Winch	12
			8.7 Added Rack for 2 BIPS	13
			8.8 Added Rack for 2 Reentry Subs	13

DOCUMENT NO. _____

GLOBAL MARINE DEVELOPMENT INC.

Newport Beach, Calif.

REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
2	22 SEP 80	R. Wallerstedt	2.0 Revised references	1
			4.2 Added note about mud and equip. in borehole revised dimensions	2
			4.3 Deleted note on mud and equip. in borehole	3
			4.5 Correct comment to"a maximum lowering speed with hydromatic brake"	3
			6.1 Corrected dimensions add Geotech Ref. dwg.	5
			6.2 Revised weight to 3350 lbs.	5
			6.3 Changed "Release" to "Handling"	5
			6.6 Changed 3 shock accelerometers to 5	7
			6.7 Added van dimensions and weight	7
			6.9 Minor revisions	8
			7.1.1 Revised dimensions, added ref dwg.	8
			7.1.2 Revised weight from 15,000 to 20,000 lbs.	10
			7.1.3 Added "the existing Glomar Challenger onboard"	10
			7.1.8 Reduced shock loads to 24G's	10
			7.1.9 Added "impact"	11
			7.6 Added "Dynamic Tensioning Equipment"	12
			8.3 Corrected location and cable length	12
			8.6 Added ships electrical power and communication requirements	13
			APPENDIX Revised Sect. 2 and 4 per Geotech recommendations.	-

DOCUMENT NO. _____

GLOBAL MARINE DEVELOPMENT INC.

Newport Beach, Calif.

REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
3	12 NOV 80	R. Wallerstedt R.Wallerstedt	2.0 Added Revised Reference Dwgs	1
			4.8 New Added Site Weather and Sea Conditions	4-11
			5.2 Changed Test Time to 4 days. Selected Cement Plug pending borehole logging	12
			6.3 Added Screwed in plugs	12
			6.4 Added Improved Description of Termination	14
			6.6 Revised Completely Data Monitoring	14
			7.1.5 Added Improved description of Release Actuation	17
			7.3.5 New Structure Description	18
			7.3.6 New Size and Weight Definition	18
			7.7 New STC Description	19
			10.0 New Support Ship	21
4	12 DEC 80	R. Wallerstedt R.Wallerstedt	Reference Added New	1
			6.2 Chgd weight to 3500 lbs	12
			6.3 Added power requirements	12
			Fig. 6.1 Revised BIP configuration	13
			6.4 Removed reference to shrinkable coating	14
			6.5 Added Tx rate of 54 K bps	14
			7.5 Add description of A-Frame	19
			7.6 Add description of heave compensator	19
			7.7 Chgd STV van dim. to 8 ft by 8 ft by 14 ft	19
			7.7.5 Change STV power to 12 KW	20

MSS DEPLOYMENT PROGRAM

AT-SEA-TEST BASELINE INTERFACE SPECIFICATION

1.0 OBJECTIVES

The objective of this interface specification is to define the performance and interface requirements for the BIP test package, reentry equipment, CHALLENGER equipment and data recording instrumentation for the baseline system demonstration. The test is to performed at an existing DSDP reentry cone site utilizing the GLOMAR CHALLENGER.

*2.0 REFERENCE

1) MSS At-Sea-Test Plan Synopsis dated revised 12 December 1980
2) Reentry Cone Assembly
3) GLOMAR CHALLENGER Plans (D-377-A002, -A003 and -A004)
4) Reentry Assembly Control Dwg. E-001-A002
5) BIP/Reentry Sub with Stinger Control Dwg. A-001-A001
6) CHALLENGER MSS At-Sea-Test Interface Drawing - E-001-A012
7) BIP Control Drawings 990-53100
8) BIP Assembly Drawing 990-53100-0101
9) At-Sea-Test Mobilization Plan GMDI RPT-001-004
10) MSS (BIP) Test Plan Phase I Geotech date 2 Dec 1980
11) MSS At-Sea-Test Operational Procedures GMDI RPT 006-003
12) EM Cable Winch Geotech Dwg. 990-53554-0101

3.0 TEST OBJECTIVES

The test objectives are to:

1) Demonstrate the baseline BIP reentry technique
2) Determine impact shock levels
3) Provide cable entanglement data for evaluation
4) Measure seismic data within a deep sea borehole
5) Recover BIP and examine

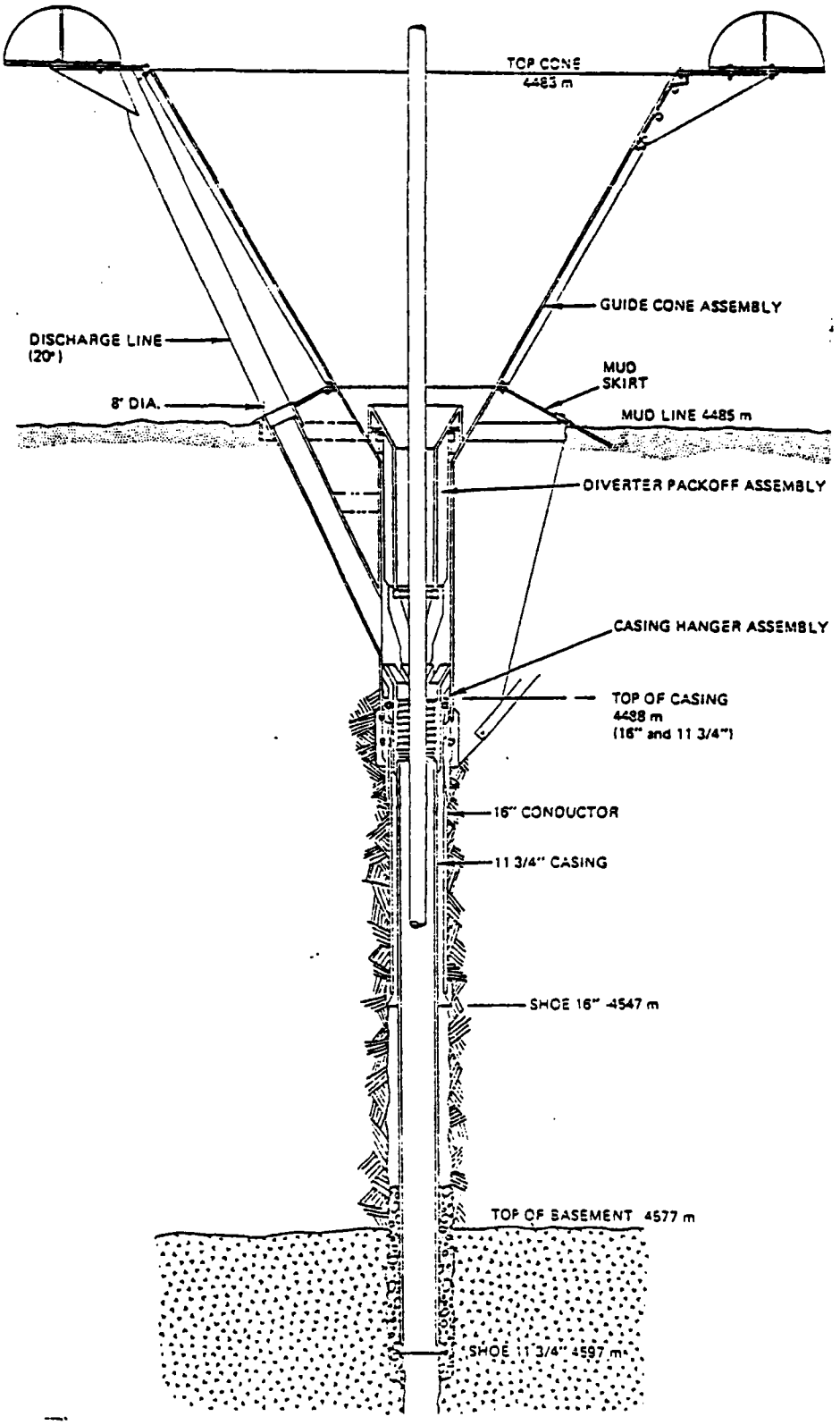
4.0 GENERAL REQUIREMENTS

4.1 Site

Reentry cone site #395A (DSDP leg 45) to be utilized is located at latitude $22^{o}45.35'N$, at longitude $46^{o}04.90'W$. Site water depth is approximately 4484 meters deep. The alternate site will be #396B located at $22^{o}55.81'N$, $43^{o}30.95'W$ at a water depth of 4450 meters.

4.2 Borehole Characteristics

The existing site #395A borehole has a drilled out diameter of 10 inches to approximately 2178 feet below the seabed. There is a 16 inch diameter by 200 feet conductor casing in the upper unconsolidated sediment area. The central portion of the borehole has been cased down to 360 feet with 11-3/4 inch casing. Refer to Fig. 4.1 for general configuration. The borehole may be caved in and/or filled upto the encased area. There is probably some broken equipment items at the bottom of the borehole.



Schematic of re-entry cone and casing at mud-line Hole 395A.

Fig. 4.1

4.3 Reentry Cone

A standard DSDP reentry cone (Ref. 2) was emplaced and is expected to be in good condition.

4.4 Drilling String

A standard DSDP 5 inch diameter S-135 drilling string is to be utilized. Maximum allowable load (static plus dynamic) is 600,000 lbs.

4.5 Reentry Velocity

The design maximum reentry velocity will be 10 ft/sec. based upon a maximum lowering speed with the Hydromatic brake.

4.6 Pressure

Subsea equipment is to be designed to 10,000 psi pressure capability.

4.7 Operational Criteria

Objective weather and operational criteria are tabulated on Table 4.1.

4.8 Site Weather and Sea Conditions (From Norda Tech. Report 74)

4.8.1 Atmospheric Pressure

Average atmospheric pressure corrected to sea level is 1020-1021 mb. The site lies on the edge of a broad 1020-1022 mb

TABLE 4.1

GLOMAR CHALLENGER

TENTATIVE MSS DEPLOYMENT LIMITS

	SEA STATE	SIGN. WAVE (FT)	WIND SPEED (KNOTS)
HANDLING MODE	5	12	24
DRILLING MODE	6	22	30
REENTRY MODE	4	17	19
POSITIONING	7	?	40
KEELHAULING	3	4	19

ULTIMATE PITCH/ROLL ANGLE $\pm$ 9°

SAFETY PITCH/ROLL ANGLE $\pm$ 7° (NEW DSDP CRITERIA)

DRILL STRING TENSILE LOAD 600,000 LBS (22,500 FT PIPE STRING - CALM)

MAXIMUM BENDING STRESS (25,000 PSI)

MAXIMUM DYNAMIC AXIAL STRESS (17,000 PSI)

high centered at 28°N, 35°W. On the average, two highs per month pass over the site, and are centered over the site 10% of the time. These highs follow a west-to-east course, no low pressure centers pass within 15° of the site from December to May. No storm tracks or hurricane tracks pass in the vicinity of the site. Storm frequency is well under 5%.

4.8.2 Winds

The site lies 3° north of the average limit of the NE trades. Prevailing winds are NE, Force 4, with 26-50% constancy. Average wind speed is 6 m/sec (11.7 kn). The percentage frequency of winds of Beaufort Force 3 or less is 55%; Beaufort Force 4 or greater is 55%; winds of Beaufort Force 8 or more have a percentage frequency well under 5%.

Average winds are tabulated below:

Direction	% Frequency	Mean Beaufort Force
N	7	3
NE	33	4
E	26	4
SE	9	3
S	7	3
SW	8	3
W	5	Data not given
NW	5	Data not given
Calm	4	----

4.8.3 Air Temperature

The mean sea surface air temperature is between 21.1° - 23.3°C (70°-74°F). Average maximum temperature is 28° (82°F); average minimum temperature is 12°C (54°F). Maximum and minimum air temperatures of record are given as 78°F (25.6°C) and 63°F (17.2°C), respectively. Frequency of temperatures under 0°C (32°F) is under 5%, presumably 0%.

4.8.4 Water Temperature

The mean surface water temperature is 22.2 - 23.6°C (72 - 74.5°F)

4.8.5 Relative Humidity

Relative humidity at the sea surface in March is expected to be 75%.

4.8.6 Precipitation

Frequency of observations reporting precipitation ranges from 5-9%, whereas precipitation frequency has been estimated at less than 1%. In any case, precipitation is infrequent, and presumably occurs as local showers. Of observed precipitation, about 80% is weak and 20% is intense. No solid precipitation has been observed.

4.8.7 Cloudiness

Precentage frequency of total cloud amounts of 2/10 or less is 28%; 2/8 or less, 35%; 5/8 or more, 30%. Percentage frequency of low cloud amounts of 7/8 or less is 98%; 4/8 or less, 80%, 6/10 or more, 20%. Values of 30% for clouded sky frequency and 33% for clear sky for February have also been reported. Frequency of total cloud cover is 4.5%.

Cloudiness is associated with winds from the NE quadrant. The area is generally partly cloudy.

4.8.8 Visibility

The frequency of visibility over 5 nm (9.26 km) is well over 95%. The frequency of visibility under 2 nm (4.63 km) is less than 0.5%. Fog frequency (visibility under 1 km (0.54 nm)) is estimated from well under 5% to less than 1%.

4.8.9 Tides

The tidal range at the site is about 0.4 m.

4.8.10 Waves

Average wave height is 1.1 m (3.6 ft) and average wave period is 5 sec. Maximum height of waves (highest 1%) is 8 m (26 ft) and maximum average wave period is 12 sec. Detailed wave data for the 5° square are shown in Predominant wave direction is from the ENE with wave periods of 6-9 sec predominating. Interpolated wave heights are:

Wave Height Equal or Exceeding	Percentage of All Waves
4 ft	48%
8 ft	11%
12 ft	2%

4.8.11 Sea State

Predominant sea direction is from the NE, with a constancy of 40-60%. Frequency of seas by height is:

Sea Equal or Exceeding	Percente Frequency
5 ft	20 %
8 ft	5%
12 ft	2%
20 ft	1%

Highest seas come from the northeast and east.

4.8.12 Swell

Predominant swell direction is from the NE with less than 40% constancy. Percent frequency of swell greater than 12 ft is 5%. There is a substantial component of swell from the NW.

4.8.13 Currents

Except for surface drift, data on currents at the site are scarce and current conditions must be largely inferred. The following water masses are found at the site:

0-500 m	Surface water (North Atlantic Central Water)
500-1500 m	Atlantic Intermediate Water and northern most portion of Antarctic Intermediate Water
1500-4500 m	North Atlantic Deep and Bottom Water
<4500 m	Antarctic Bottom Water

Depth within a range of 0.25° of the site are about 2900-4500 m. Antarctic Bottom Water would therefore not normally be found at the site. The rugged relief, however, may cause some local fluctuation in the water masses. Currents below 500 m are nonseasonal and the information presented applies to the entire year.

4.8.14 Surface Currents

The site lies within the North Equatorial Current. Current direction is W to WNW; current speeds are 0.25-0.5 kn 13-26 cm/sec), with a constancy of 33-66%. The predominant current to be westward, but significant NW and SW components are present. Resultant currents near the site have been

reported as high as 15-16 nm/day (28-30 km/day). These drift speeds suggest that 1-2 kn (100-200 cm/sec) currents may be expected occasionally, but that currents is excess of 2 kn (200 cm/sec) would be rare and would occur only in association with extreme winds.

4.8.15 Intermediate Currents

Since the site does not lie within a strong oceanic current system, currents are generally sluggish, but subject to short-term fluctuations. Between 100 and 500 m average annual current speeds are less than 10 cm/sec (0.2 kn) to the SW and WSW. Based on transport calculations, long-term average current flow is 1-3 cm/sec northward on the upper west flank of the Mid-Atlantic Ridge at 13° N, 10° S of the site.

Short term fluctuations in current speed may be expected, however. These are caused by passing eddies and by tidal forcing due to the topographic expression of the Mid-Atlantic Ridge. Root-mean-square speeds of 10-15 cm/sec (0.19-0.29 kn) and occasional maximum speeds of 30-40 cm/sec (0.58-0.78 kn) may be expected at the site. Typically, maximum speeds may have durations of several hours and occupy only a portion of the water column.

4.8.16 Bottom Currents

No specific data exist on bottom currents near the site, but some general information can be gained by examining the character of the bottom. Several bottom-photograph stations on the west flank of the Mid-Atlantic Ridge show no evidence of sediment ripples or scour, suggesting that bottom currents over 20 cm/sec (0.39 kn) are uncommon. Seismic profiles in the area show horizontally stratified sediment ponds filling lows, and a thin sediment cover on highs [6], [8]. Similarly, these profiles show no evidence of sediment scour on drifts; thus indicating an absence of strong and continuous bottom currents. The presence of horizontal stratification in the ponds, however, indicates that sediments have slumped or were transported from the highs to the ponds by turbidity currents. Turbidity currents in the sediment ponds would be relatively small but could produce current pulses in excess of 200 cm/sec (4 kn). However, annual turbidity current frequency for a pond is probably around 10^{-3} and thus should not be a problem.

5.0 SCHEDULE REQUIREMENTS

5.1 Test Period

The test period will be early March 1981.

*5.2 Test Time

The available time for actual baseline testing is 6 days. The tentative test scenario is now 4 days which does not allow for weather delays or major malfunctions. 24 hours of inhole continuously sampled and recorded seismic data will be obtained. Installation and drill out of a cement plug (estimate at 52 hours) has been deleted pending logging of borehole.

6.0 BIP TEST PACKAGE

*6.1 Configuration

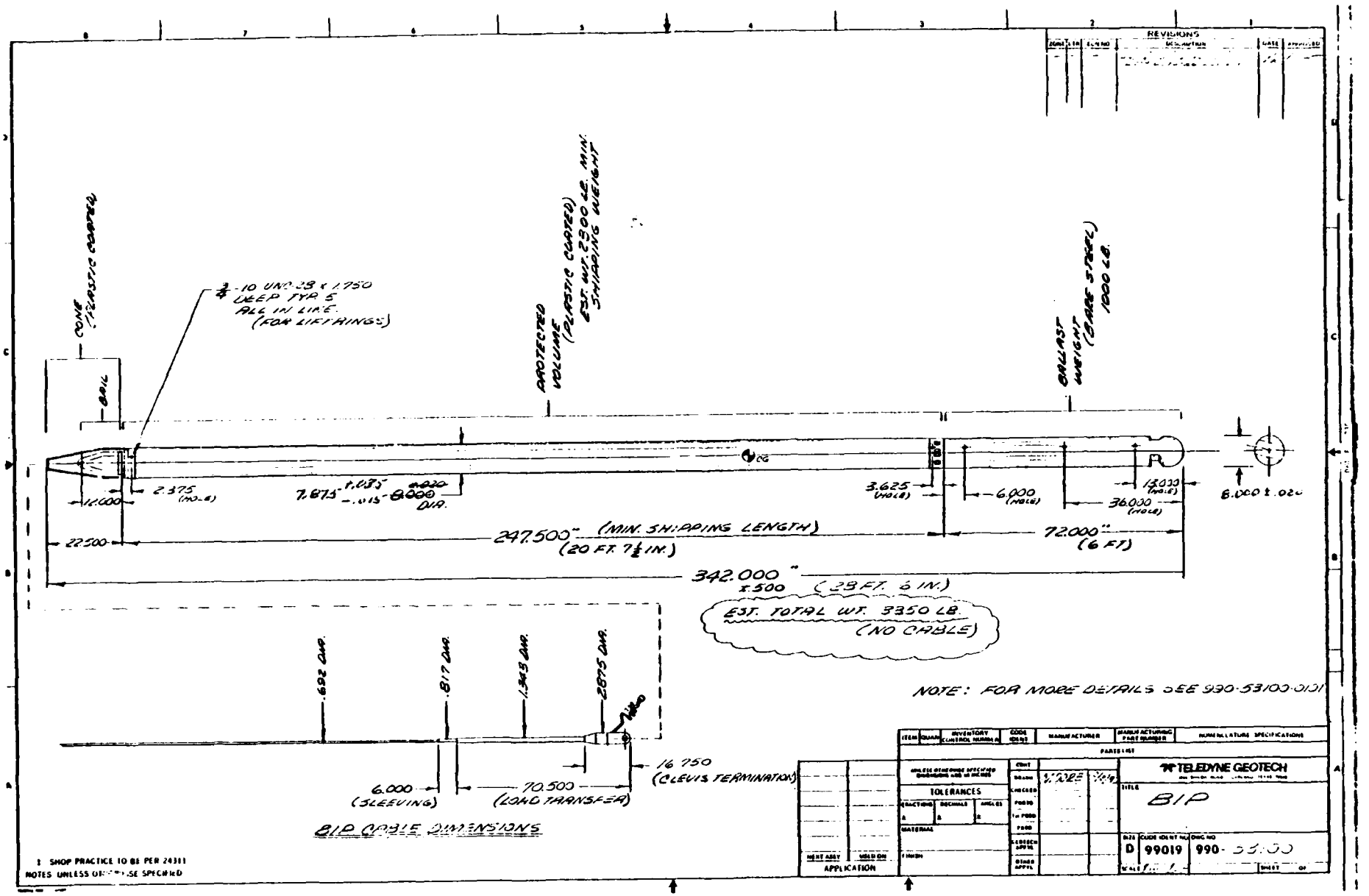
The BIP test package will be 8 inches diameter maximum by 28 feet 6 inches long. The package will have a spherical shaped bottom nose. Geotech drawing 990-53100 - Fig. 6.1 defines the general outline of the BIP test package. Two screwed in attachment plugs are available for shipboard handling.

6.2 Weight

The maximum weight of the test package will be 3500 lbs. This weight includes fairings, pressure vessels and all instrumentation and ballast.

*6.3 Power

Input power requirements will be 25 W at 150 VDC.


REVISIONS
CONE (PLASTIC COATED)
BAIL
¾-10 UNC-2B x 1.750 DEEP TYP 5 EQ IN LINE. (FOR LIFTRINGS)
PROTECTED VOLUME (PLASTIC COATED) EST. WT. 2300 LB. MIN. SHIPPING WEIGHT
BALLAST WEIGHT (CAST STEEL) 1000 LB.
CG
11.000
2.375 (NO. 4)
7.875 +.035 -.015 DIA.
3.625 (HOLE)
6.000 (HOLE)
36.000 (HOLE)
6.000 ± .020
22.500
247.500" (MIN. SHIPPING LENGTH)
(20 FT. 7½ IN.)
72.000" (6 FT)
342.000" ±.500 (28 FT. 6 IN.)
EST. TOTAL WT. 3350 LB. (NO CABLE)
.692 DIA.
.817 DIA.
1.343 DIA.
2.875 DIA.
16.750 (CLEVIS TERMINATION)
6.000 (SLEEVING)
70.500 (LOAD TRANSFER)
BID CABLE DIMENSIONS
NOTE: FOR MORE DETAILS SEE 990-53100-013
1 SHOP PRACTICE TO BE PER 24311
NOTES UNLESS OTHERWISE SPECIFIED
TELEDYNE GEOTECH
TITLE BIP
SIZE D
CODE IDENT NO 99019
DWG NO 990-53100
SCALE 1/1
SHEET

*6.4 EM Cable Termination

A water tight termination compatible with an armored coax conductor cable will utilized. The mechanical connector will be a pinned connection. The electrical technical is a water-tight connection. A sealant will be provided in the termination area.

6.5 The following instruments will be provided in the BIP. (See Appendix A)

1) 3 axis shock accelerometer
2) 2 short period - vertical seismometers
3) State of Health Instrumentation
4) Multiplexer
 Data Tx Rate will be 54 K bps.

*6.6 Data Monitoring

The following BIP data will be real time and mag tape monitored and recorded on the CHALLENGER during deployment.

Parameter	Deployment	Operational
5 channel acceleration	Waveform	-
2 channel SP seismic	-	Waveform
2 pressure	Alphanumeric	Alphanumeric
2 temperature	Alphanumeric	Alphanumeric
2 moisture	Alphanumeric	Alphanumeric
5 power	Alphanumeric	Alphanumeric
Other SOH	Alphanumeric	Alphanumeric

*6.7 EM Cable

The BIP EM Cable will be specially constructed 0.692 inch diameter armored coax conductor cable. 34,000 feet are to be provided. This allows for current, station keeping allowance, plus slacking off during data recording. Refer to Table 6.1 for design data.

6.8 Shock Capability

The BIP will be capable of surviving 10 G's of shock input along any axis.

7.0 DEPLOYMENT EQUIPMENT

7.1 BIP Reentry Sub

7.1.1 Configuration

The reentry sub will be an approximate 16 x 27 inch by 68 feet long subassembly. Dwg. E-001-A009 defines the reentry sub.

7.1.2 Weight

The BIP reentry sub plus BIP package and reentry plug will weigh a maximum of 20,000 pounds.

7.1.3 Reentry Tool

The reentry tool will be the existing GLOMAR CHALLENGER on-board sonar reentry tool.

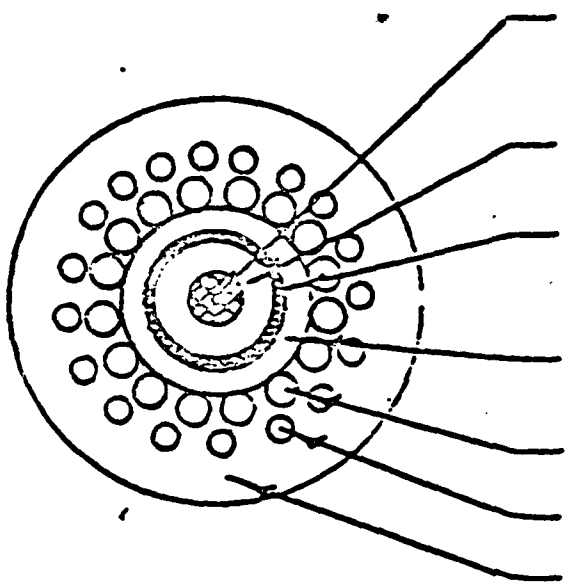
The following measurements are provided:

1) Search sonar - max. 500 ft. range - 360° Azimuth
2) Azimuth sector
3) Short range scanning

TABLE 6.1

A30084. REV. B

Description:
A SUBMARINE TOW CABLE CONSISTING OF (1) #10 AWG COAX WITH AN OVERALL DOUBLE-CAGED ARMOR AND HYTREL JACKET.



Specifications:

ELECTRICAL:	NOM CONDUCTOR DC RESISTANCE @20°C: #10 AWG:	1.08 OHMS/KFT
	COAX RETURN BRAID:	1.40 OHMS/KFT
	VOLTAGE RATING:	2,500 VOLTS RMS
	CHARACTERISTIC IMPEDANCE:	40 OHMS (REF)
	ATTENUATION AT 500 KC:	1.4 DB/KFT
MECHANICAL:	FILLED SHIELD:	TEMPLUBE ELKNG COMPOUND.
	BREAK STRENGTH:	21,000#
	WEIGHT IN AIR:	462 #/KFT
	WEIGHT IN WATER (SG = 1.027)	295 #/KFT
	TORQUE BALANCED DESIGN	

© Vector Cable Company ()

8/23/79 EF/PV

7.1.4 BIP

The BIP will be securely attached by a BIP carriage inside the reentry sub.

7.1.5 BIP Release Mechanism

A BIP release mechanism will be provided as part of the reentry sub. The BIP will be released by salt water hydraulic actuation of 2 cylinders. Four shear pins are simultaneously released causing use carriage to move to the reentry sub center release position.

7.1.6 BIP Lowering

The BIP will be guided into the center of reentry sub and lowered into the borehole at a controlled rate not to exceed 20 ft/min. The lowered position is to be monitored.

7.1.7 Drill Pipe Attachment

The reentry sub will attach through a standard tool joint to the 5 inch drill string.

7.1.8 Shock Capability

The reentry sub will designed to withstand the shock loads during reentry for maximum of 24 G's. In addition, shock isolation for the BIP will be provided to limit shock loading to 10G's.

7.1.9 Data Monitoring

The reentry tool impact data will be monitored and recorded as real time during the reentry.

7.1.10 Cable Interference

The reentry sub will be designed to prevent wear on the EM Cable during lowering and avoid contact during withdrawal.

*7.2 Sonar Reentry Tool EM Cable (Internal)

7.2.1 Size and Configuration

The sonar reentry tool EM Cable will be a standard Schlumberger 5/8 inch diameter by 7 conductor cable.

7.2.2 Strength

Max cable tensile strength is 21,000 pounds.

*7.3 BIP EM Cable Winch

7.3.1 Capability

An EM Cable Winch with slip rings will be provided to accommodate 34,000 feet of 0.692 inch coax cable.

7.3.2 Tensioning Capability

A variable constant EM Cable tensioning capability of up to 15,000 pounds is to be provided.

7.3.3 Payout Capability

A variable speed payout capability up to 20 feet per second is to be provided.

7.3.4 Monitoring

Cable tension, payout speed and length is to be recorded.

7.3.5 Structure Mounting

The winch 8 x 6 steel tubing frame will be welded directly to the special ship mounted foundation piece.

7.3.6 Size and Weight

The EM Cable Winch will be approximately 110 inches high , 91 inches wide with an overall length of 232 inches. A clearance of 30 inches on the right hand side is required for slip rings and hydraulic motor. It will weigh an approximate 38,000 lbs loaded with wire.

7.4 Lowering Cable (External)

Deleted

7.5 Overside A Frame Structure

7.5.1 Size and Configuration

A removable 28 foot long cantilevered A Frame extends approximately 18 foot over the Port side. The A-Frame is rated for 20,000 pound load. The A-Frame is supported off the casing rack and subbase structure and by a center mounted heave compensator.

7.5.2 Deployment

The A-Frame is to be deployed overside during the test.

7.6 Dynamic Tensioning Equipment

7.6.1 Description

A static heave compensation system will be attached to the cantilevered A-Frame to reduce the dynamic EM cable loading.

7.6.2 Equipment

A refurbished air/oil guideline tensioner will be utilized to provide a variable stroke support to the A-Frame. The 5 inch dia by 6 foot stroke tensioner is rated at 64,000 lbs. A 60 cubic foot accumulator will be utilized. Four nitrogen bottles will be provided. A manifold console will be provided.

7.6.3 Operation

An approximate mid position will be established by the normal static loading condition and gas presurization levels. Increased/decreased dynamic loadings will lower/raise the A-Frame end position thereby momentarily effectively paying out or pulling in more cable.

7.7 Shipboard Test Console (STC)

*7.7.1 Size and Weight

The STC will be 8 feet by 8 feet by 14 feet. It will weigh an estimated 9000 lbs loaded.

7.7.2 Shipboard Mounting

The STC shall be capable of being either bolted or welded to the deck foundation frame.

7.7.3 Construction

The STC shall be constructed so as to be completely water tight. All inside and outside wall, ceiling and floor spares shall be metal or high strength glass. Interior walls and/or components shall be constructed of fire proof material.

*7.7.4 Electrical Interface

The STC to ship electrical interface shall include the following interface signals.

a) STC Input Power

b) Voice Communications

c) Universal Standard Time (WWV) Signal

*7.7.5 STC Input Power

The input power capability will be 60 cycle 12 KW 208 VAC, 3 Phase, 4 wire WYE connected with safety ground.

8.0 CHALLENGER MODIFICATION

8.1 General Requirements

The below defined equipments installation are to be quickly accomplished in Port and must be capable of being retrofitted to original condition.

8.2 Reentry Tool Console

Deleted

8.3 EM Cable Winch (External)

Install on main deck area a new 34,000 feet diesel powered EM cable winch assembly.

8.4 A Frame

Install an approximate 10 ton overside A-Frame deployable structure amidships on the Port side.

8.5 Lowering Cable Winch

Deleted

*8.6 BIP Data Console Van

Install a real time data log and recorder van. Provide 12 KVA, 220/440V 3 phase, 60 Hz ships power to van. Also connect to ship's communication network.

8.7 BIP

A horizontal rack for 2 BIP units will be provided in the casing rack area.

8.8 Reentry Sub

A rack for 2 reentry subs will be provided.

9.0 AUXILIARY MEASUREMENT

9.1 Current Meter Array

A 1000 meter depth capability current meter, will be deployed from the support ship during the reentry tests. Current data will be provided, to GLOMAR CHALLENGER via radiotelephone from the support ship.

9.2 OBS

Two OBS (Ocean Bottom Seismic) package will be launched during the test and recovery by the support ship.

10.0 SUPPORT SHIP

10.1 Name and Type

The USS Bartlett, an AGOR type research vessel has been committed as the support ship.

APPENDIX C

AT-SEA-TEST MOBILIIZATION PLAN

NOTE: This Appendix C contains four (4) Supplimental Appendices A, B, C and E. Appendix D has been deleted.

RPT-001-004
REV. 1

AT-SEA-TEST MOBILIZATION PLAN

12 DECEMBER 1980

RPT-001-004

REV. 1

12 December 1980

AT-SEA-TEST MOBILIZATION PLAN

30 SEPTEMBER 1980

JOB 00001/TASK 240000

PREPARED FOR

NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY

NSTL STATION

BAY ST. LOUIS, MISSISSIPPI 39529

PREPARED BY

GLOBAL MARINE DEVELOPMENT INC.

2302 MARTIN STREET

IRVINE, CALIFORNIA 92715

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SECTION 1.0 - INTRODUCTION

1.1 At-sea testing is planned for the installation of a borehole instrument package in a drilled borehole which extends approximately 2,000 feet into the seabed floor, and which is in approximately 15,000 feet of water. The borehole is located in the Atlantic Ocean, at Latitude 22° 45.35' N, Longitude 46° 04.90' W. The installation is to be accomplished by the drillship GLOMAR CHALLENGER using the existing five inch drill string to implant the BIP with the aid of a reentry sub and reentry tool.

1.2 The purpose of this plan is to provide for the orderly management of the logistics and industrial efforts, from procurement of material and equipment through the installation and modifications while ensuring correct configuration and on schedule operations.

1.3 To support the modifications to, and installation of equipment on the GLOMAR CHALLENGER, a receiving and test facility will be established staffed with three administrative and technical personnel. The function of the facility staff is to receive and store equipment and material, and to supervise and coordinate the modifications to, and installation of equipment on the ship as necessary for the accomplishment of the at-sea tests. The receiving and test facility will be located at San Juan, Puerto Rico to shipyard.

1.4 This plan will be continually updated as required by schedule changes. Equipment delivery dates will be changed as more information becomes available.

SECTION 2.0 - OBJECTIVE

2.1 The general objective of the plan is to ensure the availability and readiness of all primary downhole carrier and instrumentation equipment (deep ocean instrumentation) and all support equipment for use on the GLOMAR CHALLENGER in the deployment of the marine seismic system (MSS). The principal time constraints imposed upon this objective are the arrival date of the GLOMAR CHALLENGER at San Juan, Puerto Rico on 23 January 1981, and the short duration (5 days) of the port call, and the subsequent special two-day port call at San Juan on 1 March 1981. Figure 2-1 defines the summary schedule for the MSS At-Sea-Test Program.

2.2 In accomplishment of the general objective, the following subordinate objectives are to be achieved with sufficient lead time to meet the imposed time constraints of the general objective. The techniques of preplanning, prefabrication, preassembly and logistics staging will have to be used in accomplishing the objective.

- o Procurement of primary downhole BIP reentry sub and instrumentation equipment and all BIP handling equipment and material.
- o Transportation of machinery, material and equipment from various supplier's facilities to San Juan, Puerto Rico.
- o Establishment and staffing of a Receiving and Test Facility in San Juan, Puerto Rico, approximately 45 days prior to the arrival of the GLOMAR CHALLENGER.
- o Fabrication of machinery and equipment foundations and structures and assembly of equipment components and component groups.
- o Testing of primary downhole equipment and support equipment (including preparation of test memos) as directed by the senior project engineer.
- o Maintenance and update of the at-sea-test plan through the use of management integrating techniques and by onsite progressing of scheduled work.

12 DEC 1980

SUMMARY MSS AT-SEA-TEST SCHEDULE

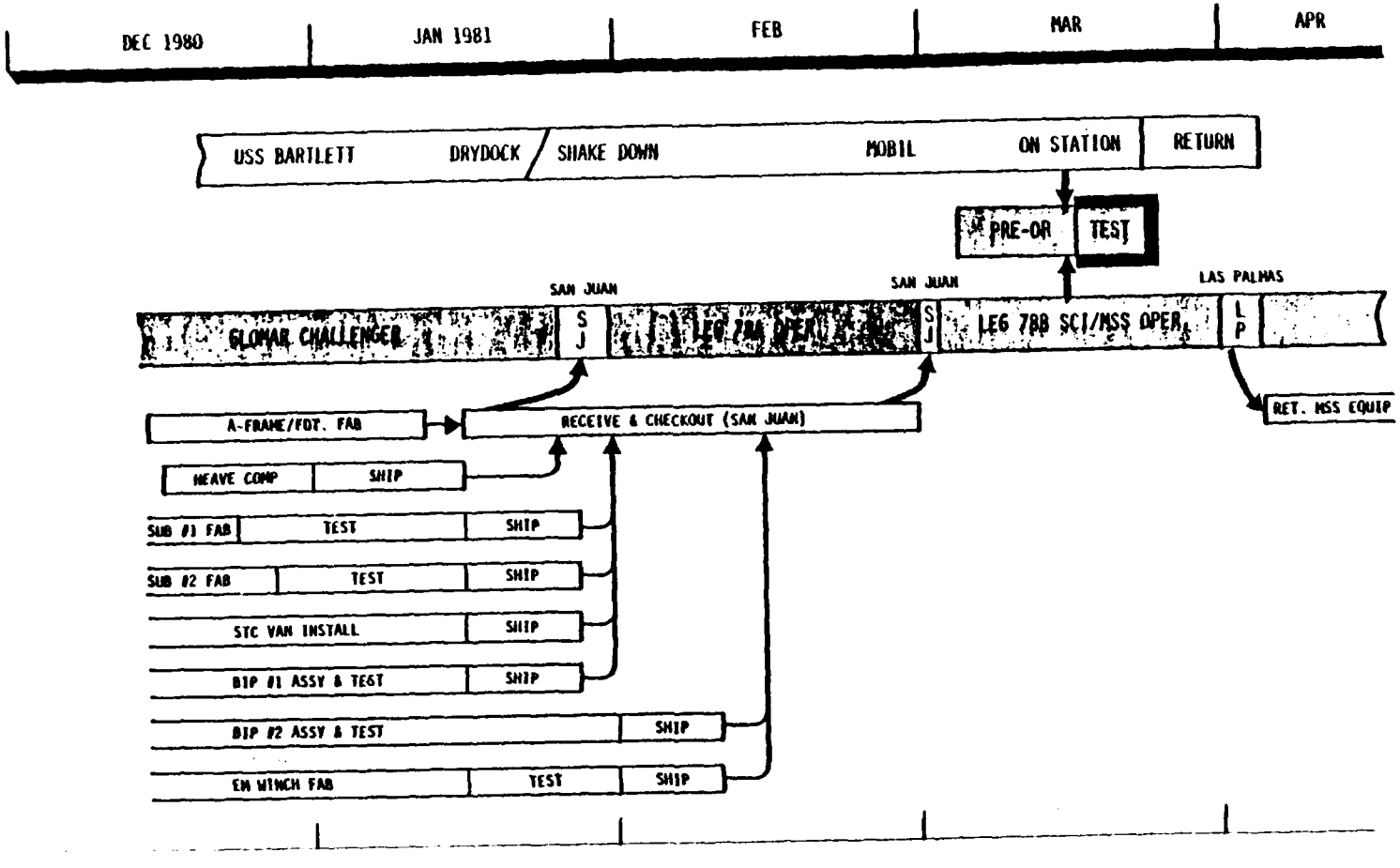


FIGURE 2-1

0006-031

- Installation of primary and support equipment, machinery and material aboard the GLOMAR CHALLENGER with modifications to the vessel as required. This includes necessary design, engineering and drawing preparation.

SECTION 3.0 - FACILITIES

3.1 SAN JUAN

A receiving and test facility will be established in San Juan, Puerto Rico. The facility will be situated at the Puerto Rico Drydock and Marine Terminals, Incorporated, a former U.S. Naval drydock and repair facility, which is fully capable of providing fabrication, ship repair and modification services, assembly area, covered storage and vessel berthing.

Puerto Rico Drydock and Marine Terminals, Inc. is situated on the south side of Isla Grande (See Appendix C), in close proximity to downtown San Juan. The receiving and test facility will be located within the PRDD&MT property and will consist of office space, and an assembly and test area of about 40,000 square feet. Mobile equipment will consist of a 15,000 pound capacity fork lift, a 6,000 pound capacity forklift, a mobile crane and several tractor drawn yard trucks. Provisions for final checkout plus minor repair of equipment is to be provided.

The facility will be opened about 15 January 1981, which is about 45 days prior to the proposed second port call of the GLOMAR CHALLENGER.

The anticipated facility staffing will provide a port engineer, a materialsman, and a secretary. All but the secretary will come from the GMDI office. The secretary will be hired locally. It is estimated that possibly 6 Geotech/GMDI technical personnel may be temporarily utilizing this facility.

All services such as janitor and security will be arranged for through the facility contractor. Equipment will be rented locally.

3.2 MARTINIQUE (Deleted)

3.3 LAS PALMAS

Facilities at Las Palmas, Gran Canaria, Spain include a larger shipyard capable of the full range of vessel drydocking and repairs. A more complete description of the port and shipyard are contained in Appendix E.

SECTION 4.0 - LOGISTICS

4.1 The principal mode of transportation to San Juan will be by roll-on, roll-off barge. This system of transportation is able to conveniently carry a variety of 40 foot transport trailers from several Gulf Coast/ Florida ports to San Juan in about 5 to 7 days transit time. Transit time is from 3 to 6 days. (See Appendix A). The barges leave Jacksonville, Florida every Wednesday and Saturday.

Truck or rail service to the barge terminals is readily available (i.e., Ryder or Southern Pacific from the West Coast) and takes eight days. Arrangements with Ryder have been made to truck the equipment from LA or Dallas/Ft. Worth area to Jacksonville, Florida.

Since there is a minimum of 24,000 lbs per trailer imposed, consolidation of material to be shipped may have to be made prior to arrival at the barge terminal. Two shipments are tentatively planned for in mid-January 1981 and early February 1981.

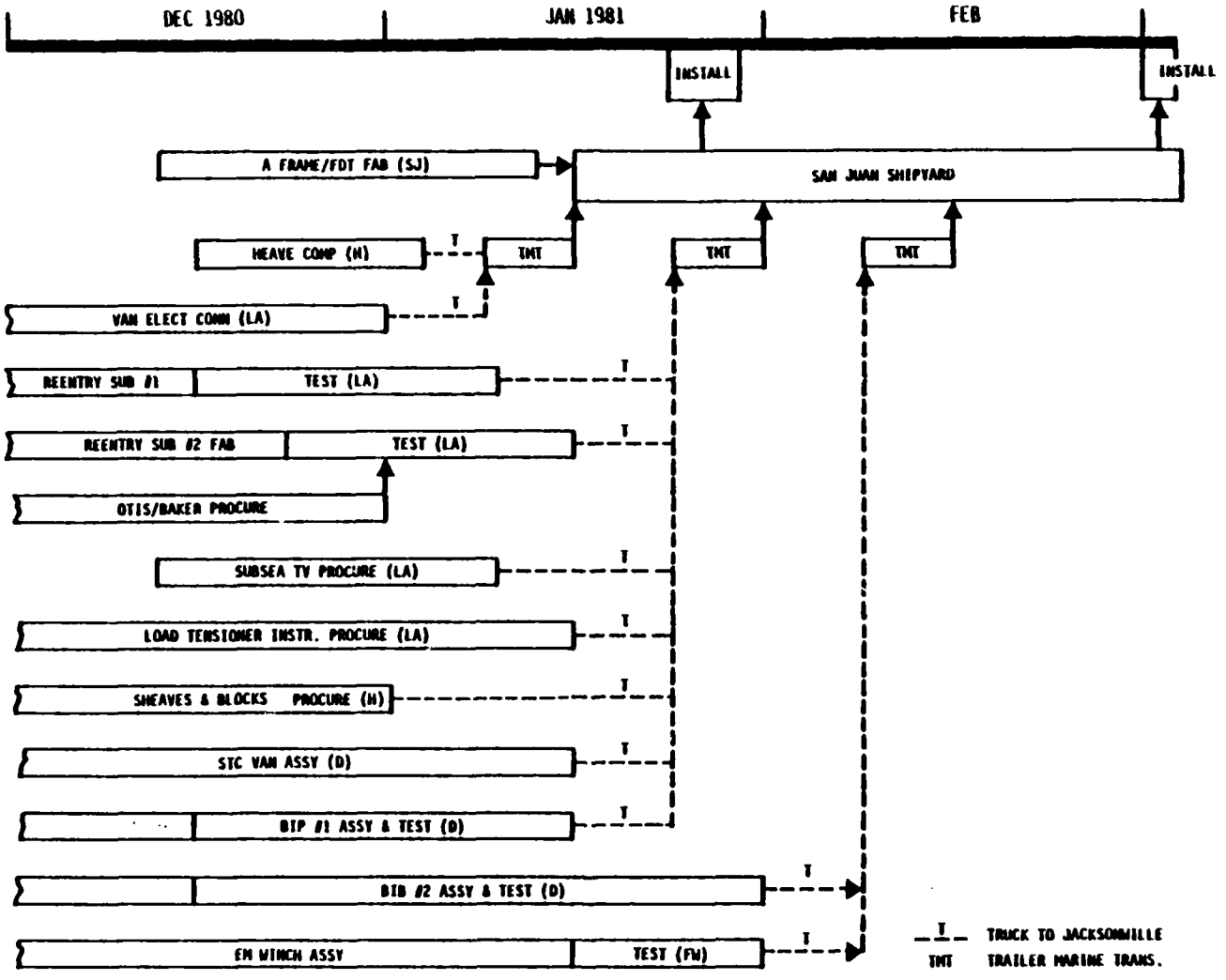
Close control of material shipping points of origin, shipping dates and shipping weights will be required in order to coordinate the shipping schedule. Information available as of this date (December 1980) indicates that all equipment furnished by Geotech Inc. will have Dallas/Ft. Worth, Texas as the initial shipping point. This material will be consolidated with other material for shipment, depending upon delivery schedules and weight.

Transportation from Las Palmas to the United States is available via regular ocean cargo vessel at a frequency of three vessels per month.

4.2 Air transportation will not be used for transport of material except as emergencies require or as back-up for surface transportation. Charter air freight (Emery) is available from Los Angeles to San Juan (approximately $60,000) and from Houston to San Juan (approximately $39,000). (Appendix B.)

4.3 The Surface Transportation Schedule (Figure 4-1) will be used to determine when material is to be shipped.

MSS AT-SEA-TEST SHIPPING SCHEDULE



0006-032

FIGURE 4-1

SECTION 5.0 - MOBILIZATION

5.1 SCHEDULE

Mobilization period is scheduled to commence about 15 January 1981, which is 9 days prior to the arrival of GLOMAR CHALLENGER IN San Juan, Puerto Rico, (Figure 5-1).

5.2 FUNCTIONS

Mobilization consists of the following functions:

- o Opening of receiving and test facility on or about 15 January. Office personnel and staff initiate control procedures, occupy office, take over rental yard equipment, storage and fabrication areas.
- o Inspect, accept, receive and store "A-Frame" and foundations scheduled for fabrication 15 December - 15 January.
- o Receive shipments of various equipments such as reentry tools, EM Cable and winch.
- o Assemble equipment.
- o Test assembled equipment which has not been tested by the manufacturer or has not been tested as an assembly.
- o Review drawings, specifications and installation sequences with shipyard for on-time and on-budget installation of shipboard equipment.
- o Supervise and coordinate installation of equipment on ship by shipyard and provide liaison between shipyard and crew.
- o Load support equipment and supplies aboard ship.
- o Conduct equipment test and check-out after installation is complete.
- o Close receiving and test facility.

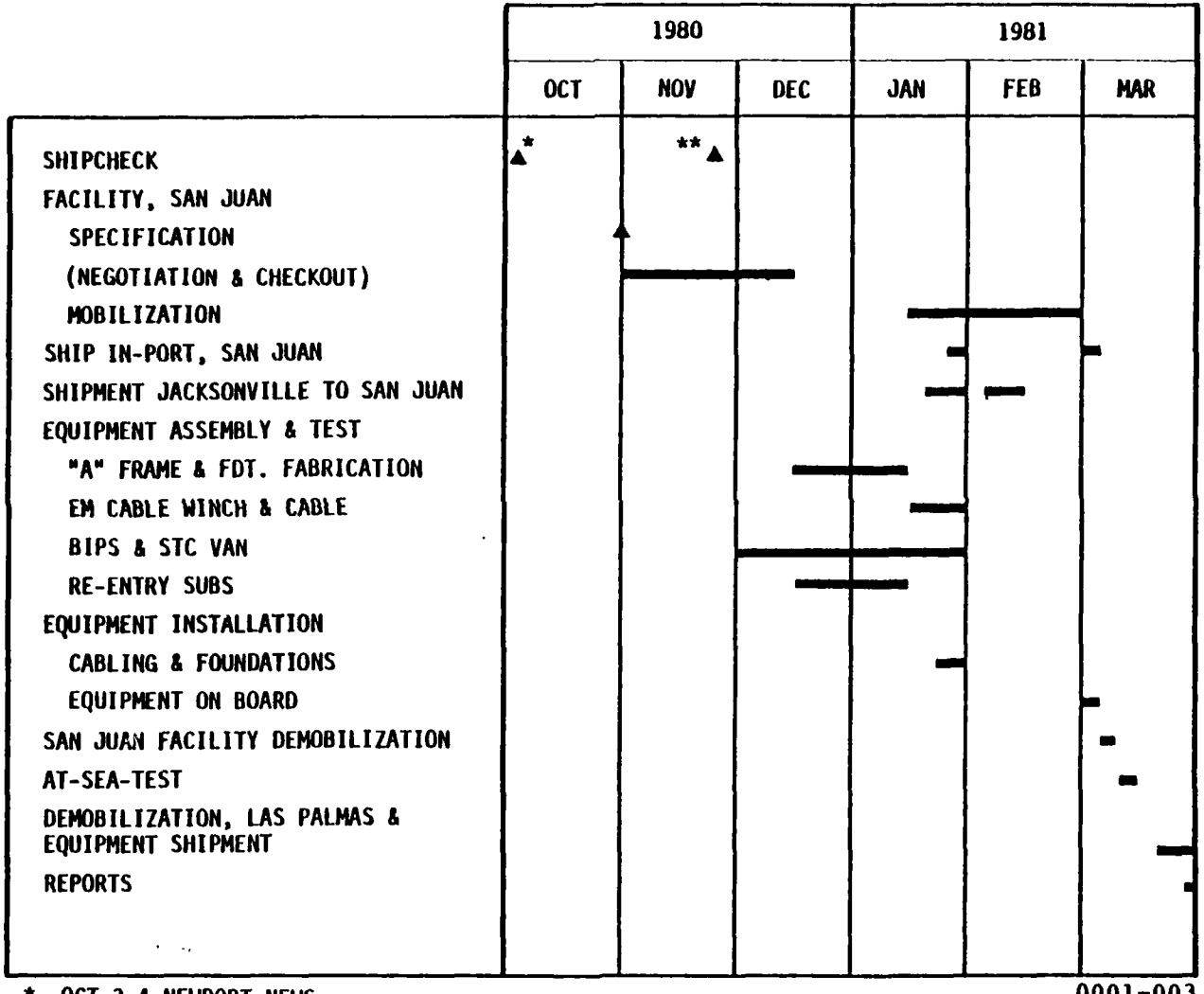


FIGURE 5-1. PROPOSED AT-SEA-TEST MOBILIZATION SCHEDULE

5.3 REPORTS

Commencing on 23 January 1981 weekly progress reports of the equipment assembly, test and installation will be prepared for submission to the project engineer and program manager. The reports will include problem areas and intended solutions.

A daily status Telex will be sent out to all concerned organizations starting at the beginning of the mobilization period, 15 January 1981.

SECTION 6.0 - SHIP MODIFICATIONS AND EQUIPMENT INSTALLATION

6.1 PLANNING

For planning purposes, basic ship modifications will be accomplished in San Juan, Puerto Rico at the Puerto Rico Drydock and Marine Terminals yard during the GLOMAR CHALLENGER port call of 23 - 28 January 1981.

Equipment installation will be accomplished either at San Juan after the Fort-de-France port call approximately 28 February to 2 March 1981. Currently, DSDP has indicated that they will reschedule the return trip to San Juan prior to the At-Sea-Test.

6.2 SHIP MODIFICATIONS

The extent of ship modifications will be determined from available drawings and verified by ship check on the GLOMAR CHALLENGER about the end of September at Newport News, Virginia. The expected modifications include:

- "A-Frame" support structures.
- EM Cable winch foundation.
- Deck stiffening in way of BIP control console van.
- Removal/relocation of interferences in way of equipment installations.
- Installation of electrical power and lighting cabling, distribution panels and controllers to service new equipment.

To make room for this installation, a wireline reel must be moved and possibly a deck cleat modified. It appears that the stored reentry cones will not have to be revised.

6.3 EQUIPMENT INSTALLATION

To provide means of deploying the BIP monitoring of the BIP, the following equipment installations will be accomplished:

- o Placement of the "A-Frame," main deck port side, Frames 110-118.
- o Placement of the EM Cable winch inboard of the "A-Frame" with drum aligned to "A-Frame" head.
- o Deck mounting of BIP control console van in a suitable location under the casing rack.
- o Casing rack sleepers to accommodate reentry sub.

6.4 EQUIPMENT DATA SHEETS

Separate data sheets follow.

6.4.1 Borehole Instrumentation Package (BIP)

- Description: The package consists of a shock accelerometer, a sensor and additional electronics section, a downhole electronics section, an inert section and a connector section (as shown on GMDI Drawing E-001-A001, Alt. B, Section 4-A). The main body of pressure vessel of the BIP will be alloy steel and filled with helium at atmospheric pressure. The shock absorber will be rubber shock isolation designed for a maximum lowering velocity of 20 FPM. The EM Cable terminal connections will be structurally pinned with a separate connector plug. The BIP is 8" in diameter and is 28'6" long.
- Responsibility:
 - Requisition - Will be provided by Geotech.
 - Receiving (San Juan) - GMDI construction.
 - Test - Geotech.
- Drawings: GMDI E-001-A001, Section 4-A.
- Subassemblies: N/A, will be received as a unit.
- Interfaces:
 - EM Cable - Connect up and seal.
 - Reentry Sub - Install in BIP centering devices and hook-up to BIP release mechanism (see GMDI Drawing E-001-A001, Elevation 2-C).
- Shipping: From: Houston
 To: San Juan
 Via: Truck to Jacksonville. Barge to San Juan.
 Available: 1/15/81 and 1/31/81
 Deadline: 1/31/81 and 2/15/81
 Arrival, San Juan:
- Installation: Must be installed in reentry sub body in accordance with GMDI Drawing E001-A001.
- Test: To be done by Geotech at receiving facility. After EM Cable hook-up, Geotech is to check out with van and EM Cable.

6.4.2 Sonar (Reentry Tool)

- o Description: Edo Western Model 516.
- o Responsibility:
 - Requisition - No formal requisition, but must be arranged for, to be available at San Juan facility for fit test in reentry sub body, part of onboard equipment.
 - Receiving (San Juan) - GMDI construction.
 - Test - GMDI engineering.
- o Manufacturer: Edo Western.
- o Drawings: Edo Western
 GMDI E-001-A001, Section 30D.
- o Subassemblies: None, delivered as a unit.
- o Interfaces:
 - Sonar Stinger - Must fit sonar stinger which will be fabricated in San Juan.
 - Sonar Cable - Hook-up to be done by ship.
- o On Board
- o Installation: Down through drill pipe, done by ship.
- o Test: Fit test in reentry sub body and sonar stinger - GMDI engineering.

6.4.3 Shock Sub (Deleted)

6.4.3 Heave Compensator (A-Frame)

Heave compensator and associated equipment will be installed on shipboard in conjunction with A-Frame. Manifold and bottle supports will be fabricated at San Juan shipyard. Nitrogen bottles will be procured through shipyard.

6.4.4 EM Cable

- Description: 39,000 feet, spaced high tensile steel, vector double armored (axial), polyurethane Hytrel coating 0.692 thickness, 21,000 lbs rated breaking strength - torque balanced.
- Responsibility:
 - Requisition - Provided by NORDA.
 - Receiving - GMDI construction.
 - Test - NORDA/GMDI.
- Supplier: NORDA.
- Drawing or Specification: N.A.
- Subassemblies: Lugs and terminals.
- Interfaces: Connect up to BIP control console van and to BIP (see Data Sheet 6.4.1). Cable will have to be sealed at BIP connector section. 32" diameter fairlead sheave required for deployment - will mount on EM winch structure.
- Shipping: (Will be spooled on EM Cable winch reel but shipped separately)

 From: Fort Worth with EM Winch
 To: San Juan
 Via: Truck/Barge, Jacksonville
 Available: 1/31/81
 Deadline: 2/15/81
 Arrival, San Juan:
- Installation: Cable and winch will be installed as a unit.
- Test: Geotech will devise test for continuity and conduct test.

6.4.5 BIP Control Console Van (STC)

- o Description: 14' x 8' x 8' on 4" x 4" steel skids. Contains control and monitoring instrumentation equipment for BIP and has connection box for EM Cable.
- o Responsibility:
 - Requisition - Provided by Geotech.
 - Receiving - GMDI construction.
 - Test - NORDA/GMDI.
- o Supplier: Geotech.
- o Drawing or Specification: N.A.
- o Subassemblies:
 - Foundation
 - Terminal Block
- o Interfaces: EM Cable will connect up to connection box with terminal strip. Lighting and power cable, previously run in San Juan will be connected.
- o Shipping: From:
 To: San Juan
 Via: Truck to Miaimi, TMT Barge to San Juan, thence to Martinique.
 Available: 1/15/81
 Deadline: 1/21/81
 Arrival, San Juan: 1/28/81
- o Installation: Installed as a unit, on foundation to be installed in San Juan about 23 January 1981.
- o Test: Test will be devised by GMDI/Geotech. GMDI will supervise test.
- o Problem Area: Will require USCG certification or waver.

6.4.6 EM Cable Winch

- Description: Manufacturer: S.P. Eng. Diesel driven, single drum winch with power take up and pay out. 20,000 pound maximum line pull with constant tension of 10,000 lbs maximum. Winch base is approximately 8' x 20'. Weight is 38,000 lbs.
- Responsibility:
 - Requisition - Provided by Geotech.
 - Receiving - GMDI construction.
 - Test - Geotech.
- Supplier: Pengo.
- Drawing or Specification: N.A.
- Subassemblies:
 - EM Cable will be spooled on when delivered.
 - Fairleads.
 - Slipping or rotoseal.
- Interfaces:
 - Will have to be positioned so as to lead to "A-Frame" sheave.
 - Install muffler and exhaust pipe so as not to contaminate ventilation and install insulation or mesh screw for personnel protection.
 - Install wireway from winch to BIP CC van.
- Shipping: From: Dallas, Texas
 To: San Juan or Martinique
 Via: Truck to Miaimi, TMT Barge to San Juan, and/or Martinique.
 Available: 1/31/80
 Deadline: 1/31/81
 Arrival San Juan: 2/15/81
- Installation: Installed as a unit, on foundation which will be installed in San Juan about 23-28 January 1981.
- Test: GMDI will establish calibration test at shipyard devise test. Continuity check through slipping/rotoseal assembly will be done in conjunction with EM Cable continuity check.
- Training of GMDC crew members (2) required prior to shipment.
- Pengo to have service reps in San Juan during late February 1981 for final installation.

6.4.7 BIP Control Console Van Foundation (STC)

- o Description: Configured to retain van skids to prevent movement of van when ship is in roll and pitch.
- o Responsibility:
 - Design: GMDI Engineering.
 - Requisition - GMDI construction.
 - Specification - GMDI construction.
 - Installation - GMDI construction.
- o Supplier: Puerto Rico Drydock and Marine Terminals, Inc.
- o Drawing: _____
- o Specification: SPC 006-003 - Revision 1 MSS 8
- o Interfaces: Foundation will have to tie into ship structure. Additional stiffening of ship structure may be required.
- o Fabrication: PRDD&MT
 - Drawings - 30 November 1980
 - Specification - 30 November 1980
 - P.O. Issued - 15 December 1980
 - Installation - 23-28 January 1981

6.4.8 EM Cable Winch Foundation

- o Description: Configured to match winch base bolt flange.
- o Responsibility:
 - Design - GMDI Engineering.
 - Requisition - GMDI construction.
 - Specification - GMDI construction.
 - Installation - GMDI construction.
- o Supplier: Puerto Rico Drydock and Marine Terminals, Inc.
- o Drawing: E-001-A025
- o Specification: SPC 006-003 - Revision 1 MSS 5
- o Interfaces: Will tie into ship structure. Additional stiffening of ship structure may be required.
- o Fabrication: PRDD&MT.
 - Drawings - 10 December 1980 (Rev. 1)
 - Specification - 30 November 1980
 - P.O. Issued - 15 December 1980
 - Installation - 23-28 January 1981

6.4.9 "A-Frame" and Foundations

- o Description: 10 ton capacity, box girder construction.
- o Responsibility:
 - Design - GMDI Engineering.
 - Requisition - GMDI construction.
 - Specification - GMDI construction.
 - Installation - GMDI construction.
- o Supplier: Puerto Rico Drydock and Marine Terminals, Inc.
- o Drawing: E-001-A022
- o Specification: SPC 006-003 - Revision 1 MSS 3
- o Interfaces: Foundations tie into ship structure at starboard deck edge FRS 134 & 142 and to casing rack at FRS 135 & 140.
- o Fabrication: PRDD&MT.
 - Drawings - 10 December 1980 (Rev. 1)
 - Specification - 30 November 1980
 - P.O. Issued - 15 December 1980
 - Installation - 23-28 January 1981
- o Dynamic tensioning equipment may be added.
- o Structutal load test required.

6.4.10 Miscellaneous Handling Equipment, Tools and Fittings

Preliminary identification of this category of equipment is listed below. Individual data sheets will be made out, if appropriate, when final identification is made.

- Cable Protector - 2" x 5' XXS pipe split and hinged (E-001-A013)
- EM Cable Sheave Block - 36" diameter
- Survey tools for pipe alignment
- Baker Model "K" Lock Subassembly (2)
- Baker Special Blank Bottom Adapter (2)
- Baker Model "M1" Probe (1)
- Otis Fishing Tool (2)
- Head Sets
- Handling Sling for BIP
- Handling Sling for Reentry Sub
- Rack for Reentry Subs
- EM Cable Handling Sleeve Attachment
- Keelhaul Line for EM Cable
- "A-Frame" Self-Locking Snatch Block - 36" diameter
- Running Fairleader with mechanical/acoustic release
- Tools
- Martin Decker Load Cell and payout speed inst.
- Sabsia TV Camera and Console
- TV overside pipe structure and mounts
- 36 inch Snatch Block (NORDA) (20,000 lb Cap.)
- 36 inch Sheave (NORDA)
- 3 Snatch Blocks (NORDA)

SECTION 7.0 - AT-SEA-TEST

7.1 The At-Sea-Test will take place at reentry cone site #395A, Latitude 22° 45.35'N, Longitude 46° 04.90'W which is along the San Juan/Las Palmas leg 78 of the GLOMAR CHALLENGER's schedule. The time frame for the At-Sea-Test is between 3 - 20 March 1981.

7.2 Prior to the ship departure all installations, modifications and equipment tests will be completed, all briefing of ship's personnel will be accomplished, and all known problems resolved so that the At-Sea-Test can proceed without difficulty and delay once the ship leaves San Juan.

7.3 The planning effort is intended to reflect all of the interfaces of procurement, transportation, equipment assembly, vessel modification and activity support to ensure the above.

SECTION 8.0 - DEMOBILIZATION

8.1 Demobilization will occur in two phases.

8.1.1 The demobilization of the receiving and test facility in San Juan from about 3 March to 5 March 1981 will be accomplished. This will include:

- o Terminating telephone service.
- o Terminating office, storage yard, yard equipment and automobile rentals.
- o Return shipment, sale or disposal of all excess equipment.
- o Closing of all local contractor and vendor accounts.

8.1.2 The removal of all ship equipment that was previously installed in San Juan will be accomplished in Las Palmas, Grand Canary Island at the Astican Shipyard. This equipment is to be shipped, sold or scrapped as directed by the respective owner. This equipment includes:

- o EM Cable and winch.
- o BIP control console van.
- o BIP's (2).
- o "A-Frame," sheaves and fairleads.
- o Reentry sub's (2).
- o Miscellaneous tools and equipment.
- o Heave compensator

All equipment removed from the ship will be crated for shipment to respective owners in the United States. Care must be taken to comply with Spanish customs requirements which are explained in Section 9.0. Equipment foundations and foundation stiffening will be removed by scarfing, chipping and grinding and then stored. Electric cabling, connection boxes controllers, etc., will be removed and crated for shipment back to the United States or may be disposed of in Las Palmas if customs regulations permit.

The GLOMAR CHALLENGER is to be returned to the configuration necessary to continue work on the regular contract. At DSDP discretion, some of the equipment may remain onboard preparatory for June 1982 deployment.

8.2 The Port of Las Palmas is located on Grand Canary Island in the Spanish Canary Islands. It is a deep water port with the facilities of a large shipyard capable of effecting all types of repairs. A more complete description of the port and shipyard are contained in Appendix E.

SECTION 9.0 - CUSTOMS

9.1 FORT-DE-FRANCE, MARTINIQUE

(Deleted)

9.2 LAS PALMAS, GRAND CANARY ISLAND

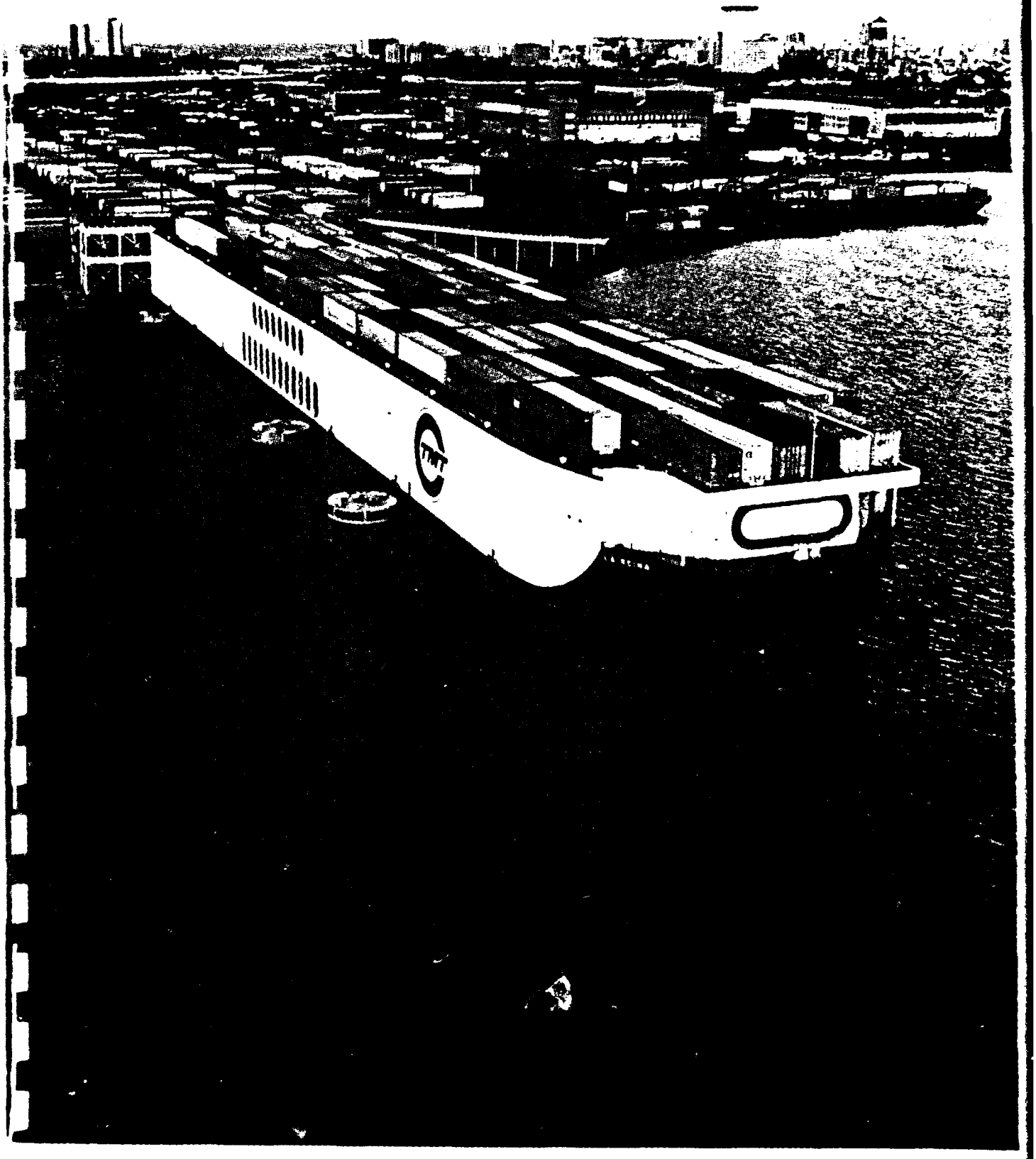
Preliminary liaison with Memasantes International, S.A., which is a general agent and service company in Las Palmas, indicates that there will be no difficulty in landing the equipment to be removed from the ship for crating and shipping back to the United States. Customs will require all paperwork to be complete. This includes packing lists, with number of pieces, weight, description, value and a statement that the shipment is in transit to the United States.

Contact: Memasantes International, S.A., 95212 MEMA-E
ATTN: Alain Florentin, Vice-President, Operations
Antonia Maria Manrrique, #4 La Cornisa, Las Palmas
Gran Canaria, Spain
Telephone: 27-3650

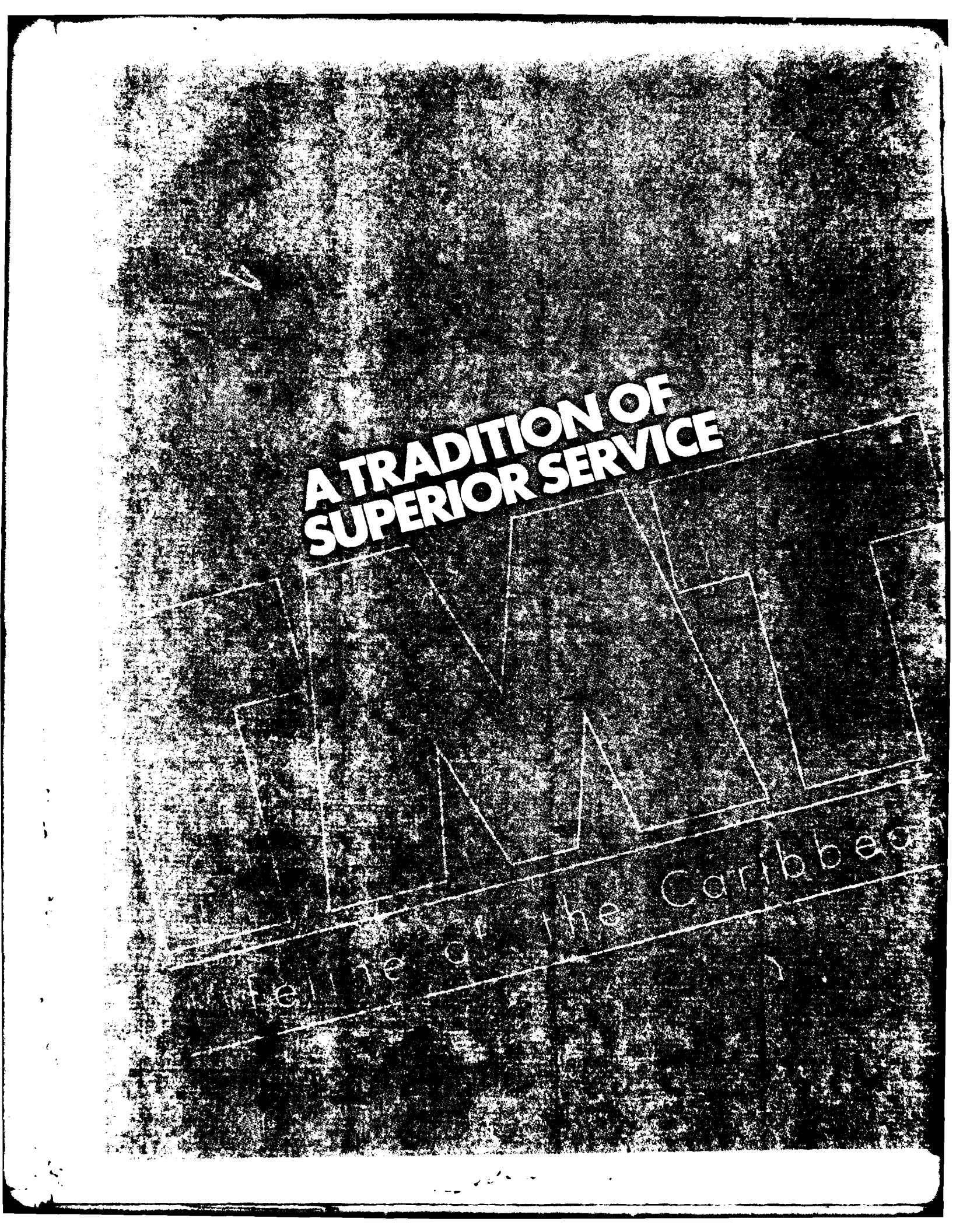
APPENDIX A

TRAILER MARINE TRANSPORT SERVICES

TRAILER MARINE TRANSPORT CORPORATION



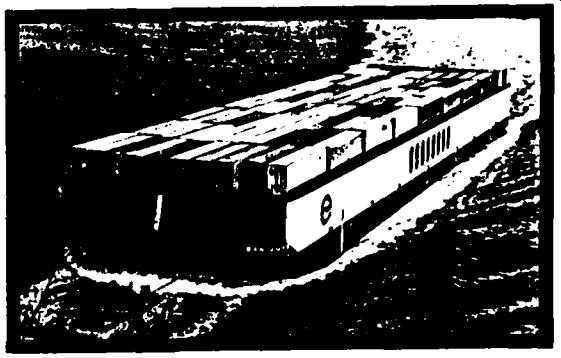


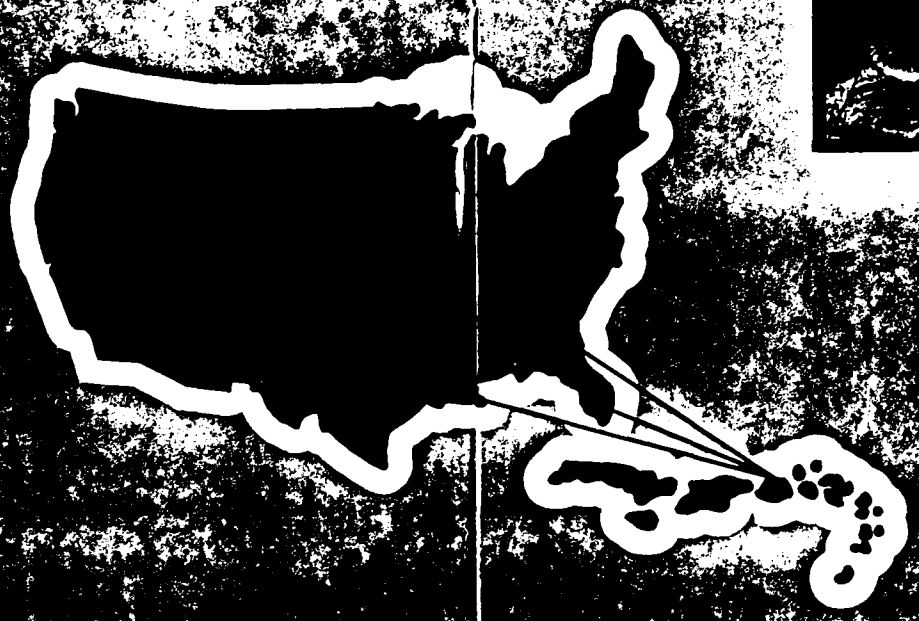

A TRADITION OF
SUPERIOR SERVICE
Caribbean

Trailer Marine Transport Corporation introduced intermodal cargo movement to the Caribbean in 1954. And we've been leading the development of Caribbean cargo-transport options ever since.

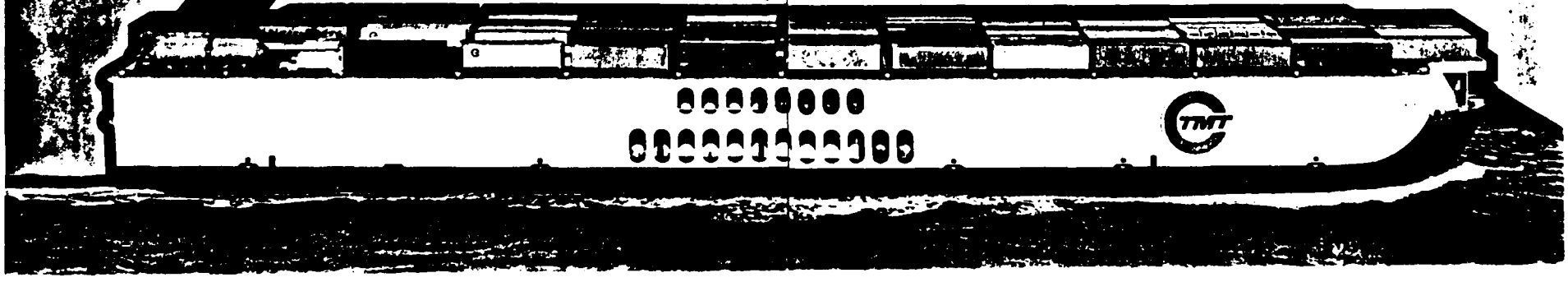
Today TMT has the largest roll-on/roll-off capacity of all Caribbean carriers operating in the South Atlantic or Gulf. We offer more frequent sailings to and from the islands, on more RO/RO passage, to more Caribbean destinations. The TMT fleet includes the largest roll-on/roll-off barges in the world, as well as specialized tank, refrigerated and dry bulk trailers. And TMT's equipment and service capabilities are backed by one of the strongest and most dependable cargo-movement systems in the business.

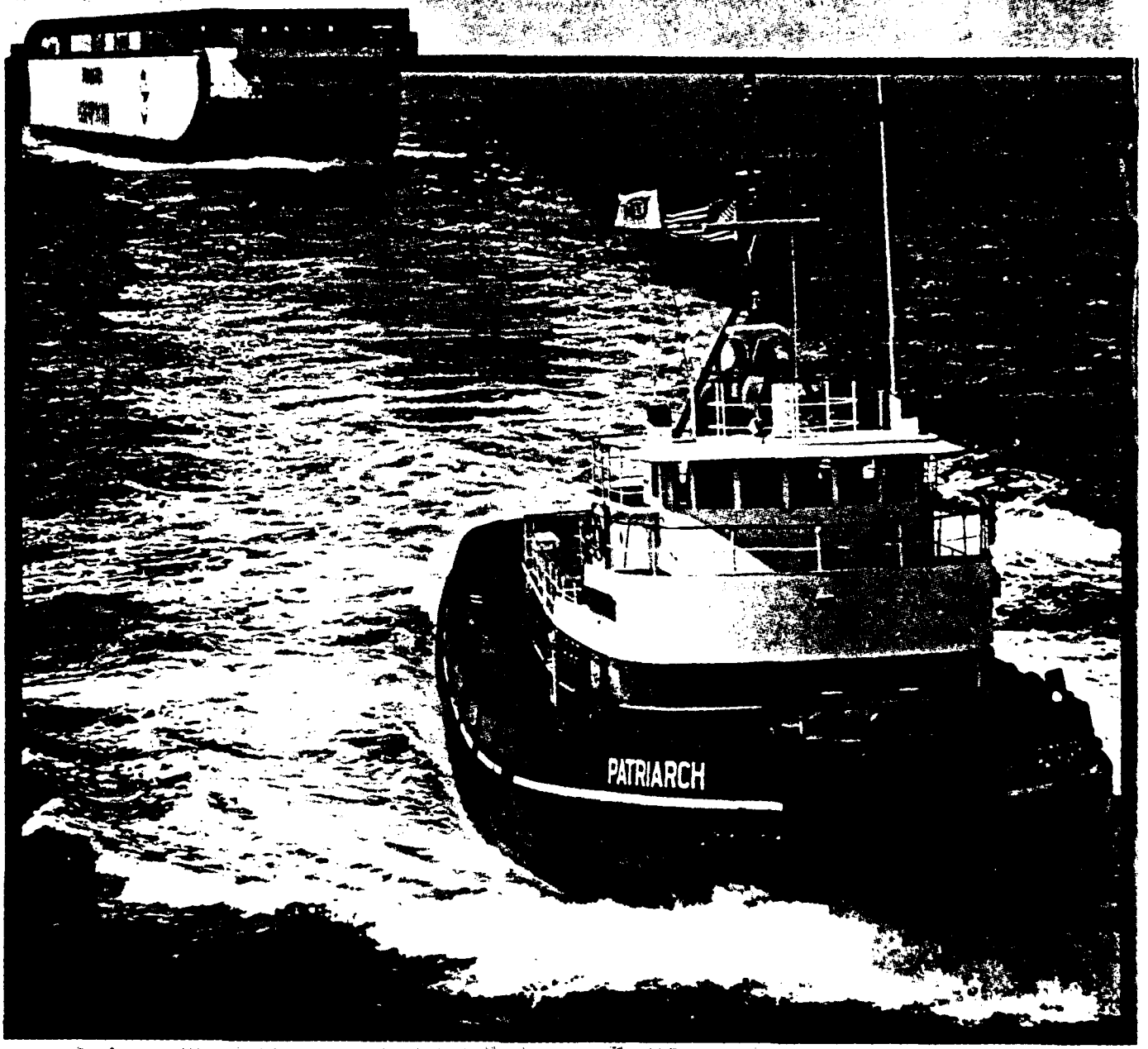
TMT will continue as the leader in development of new equipment, facilities and innovative services. That's what the TMT tradition is all about.

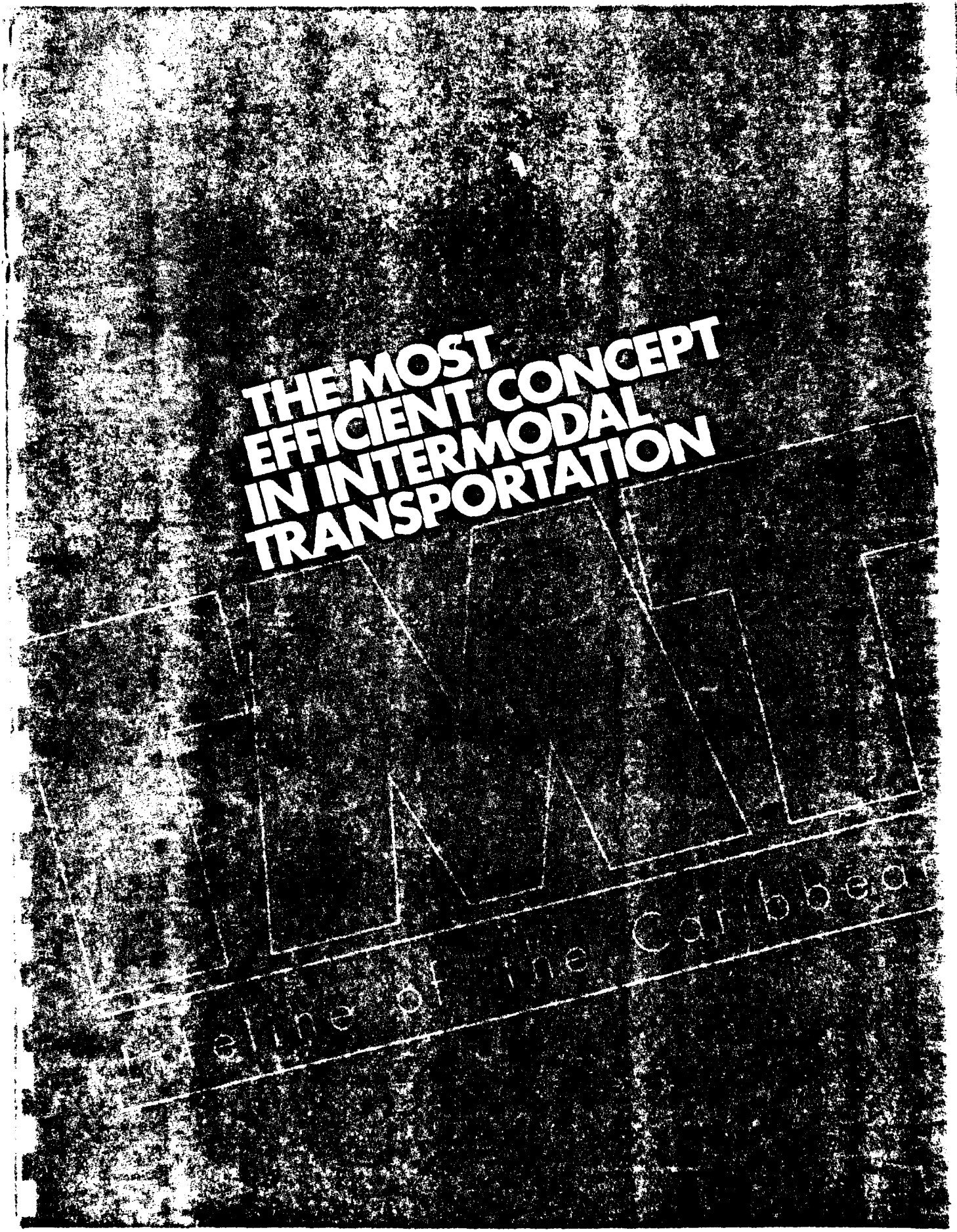




TMT's mammoth triple-deck barges measure 580x105x57 feet and are capable of carrying up to 374 forty-foot trailers each.




PATRIARCH


THE MOST
EFFICIENT CONCEPT
IN INTERMODAL
TRANSPORTATION
A
e line of the Caribbean

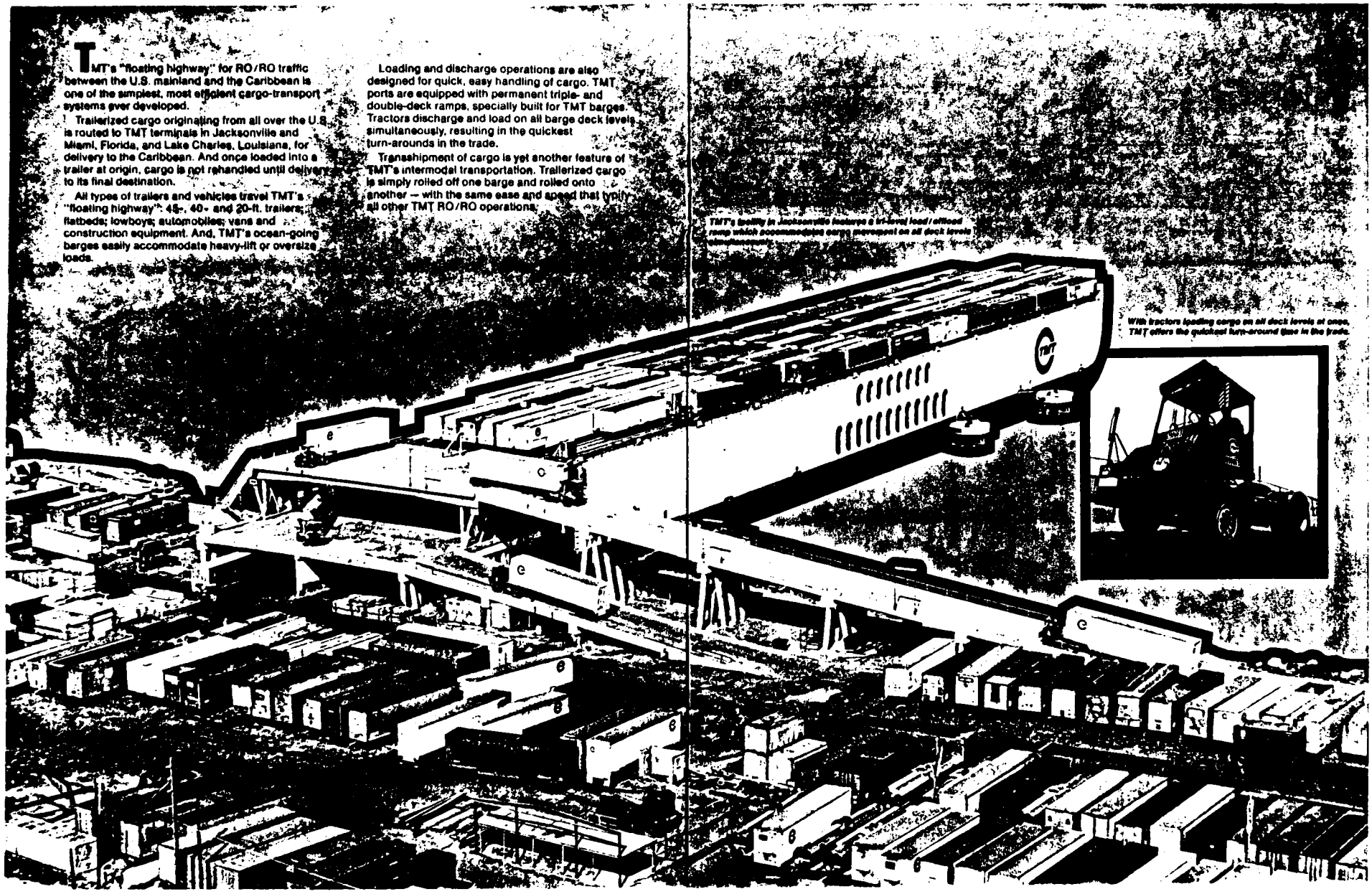
TMT's "floating highway" for RO/RO traffic between the U.S. mainland and the Caribbean is one of the simplest, most efficient cargo-transport systems ever developed.

Trailerized cargo originating from all over the U.S. is routed to TMT terminals in Jacksonville and Miami, Florida, and Lake Charles, Louisiana, for delivery to the Caribbean. And once loaded into a trailer at origin, cargo is not rehandled until delivery to its final destination.

All types of trailers and vehicles travel TMT's "floating highway": 45-, 40- and 20-ft. trailers; flatbeds; lowboys; automobiles; vans and construction equipment. And, TMT's ocean-going barges easily accommodate heavy-lift or oversize loads.

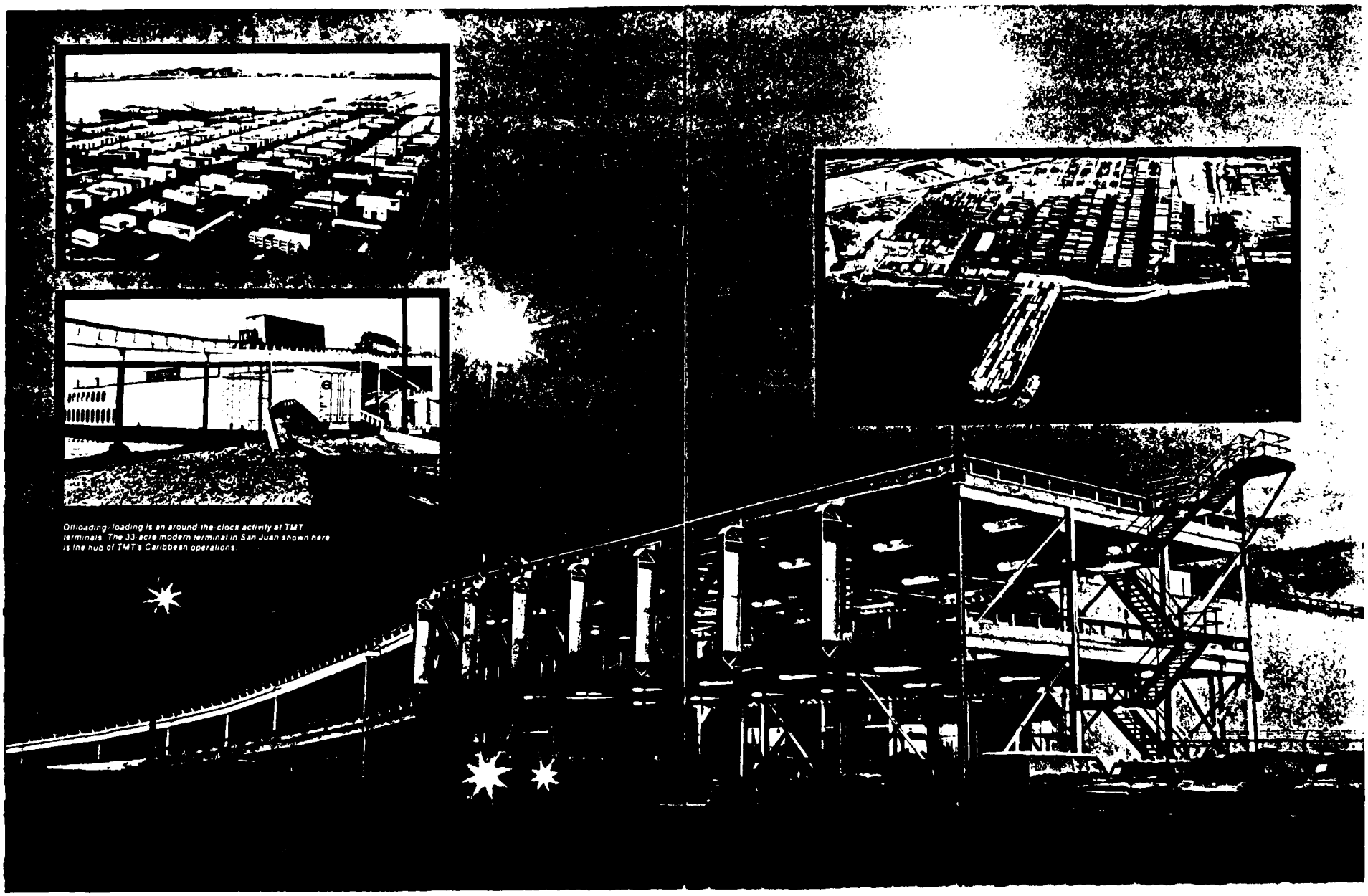
Loading and discharge operations are also designed for quick, easy handling of cargo. TMT ports are equipped with permanent triple- and double-deck ramps, specially built for TMT barges. Tractors discharge and load on all barge deck levels simultaneously, resulting in the quickest turn-arounds in the trade.

Transshipment of cargo is yet another feature of TMT's intermodal transportation. Trailerized cargo is simply rolled off one barge and rolled onto another — with the same ease and speed that typify all other TMT RO/RO operations.

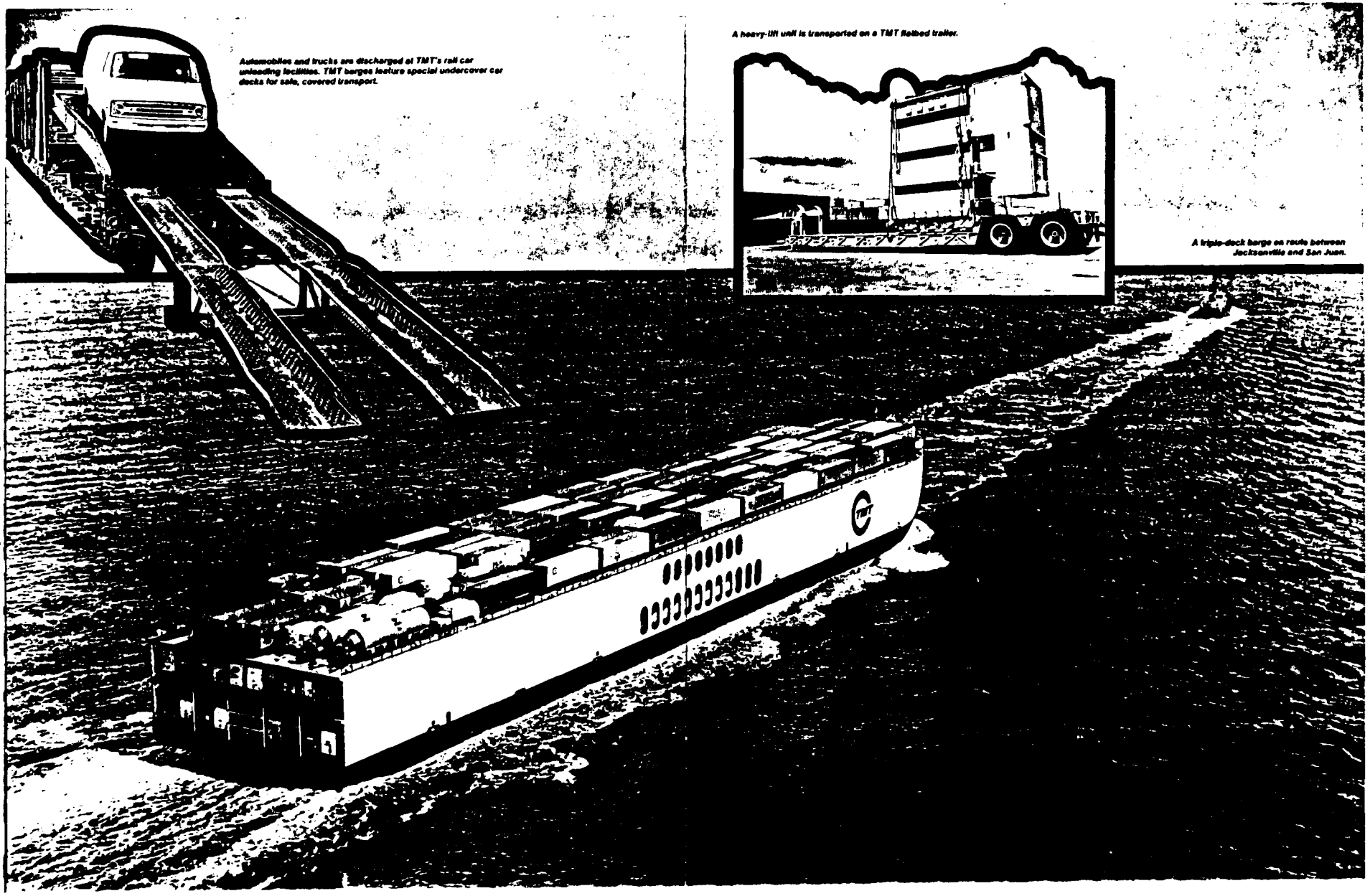


TMT's facility in Jacksonville features a tri-level load / offload ramp which accommodates cargo movement on all deck levels simultaneously.

With tractors loading cargo on all deck levels at once, TMT offers the quickest turn-around time in the trade.



Offloading/loading is an around-the-clock activity at TMT terminals. The 33 acre modern terminal in San Juan shown here is the hub of TMT's Caribbean operations.



Automobiles and trucks are discharged at TMT's rail car unloading facilities. TMT barges feature special undercover car decks for safe, covered transport.

A heavy-lift unit is transported on a TMT flatbed trailer.

A triple-deck barge on route between Jacksonville and San Juan.

MODERN MARINE
EQUIPMENT
DESIGNED FOR
CONSISTENT
PERFORMANCE

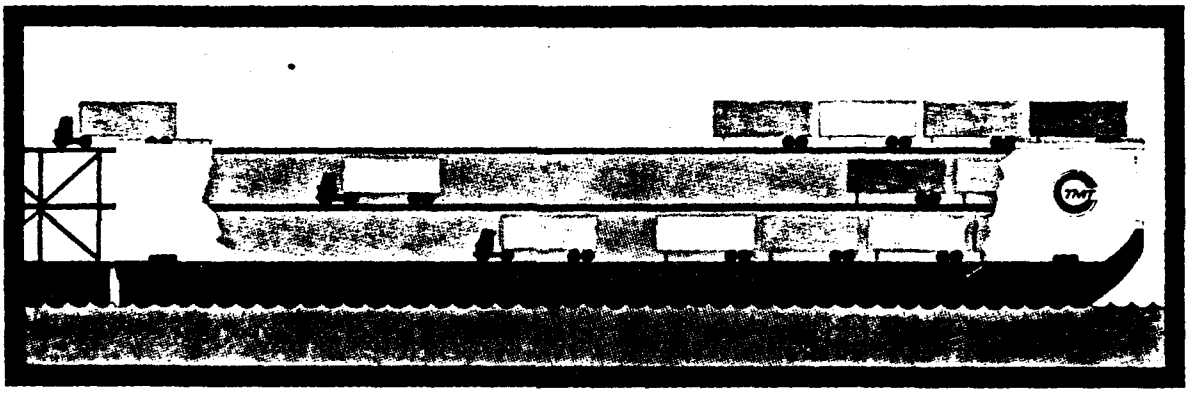
From TMT's single-deck barges of 1954 to the giant 400x100-ft. double-deckers introduced in the mid-1970's to our mammoth triple-deckers in service today — the RO/RO barge has been the key to TMT's cargo-transport service.

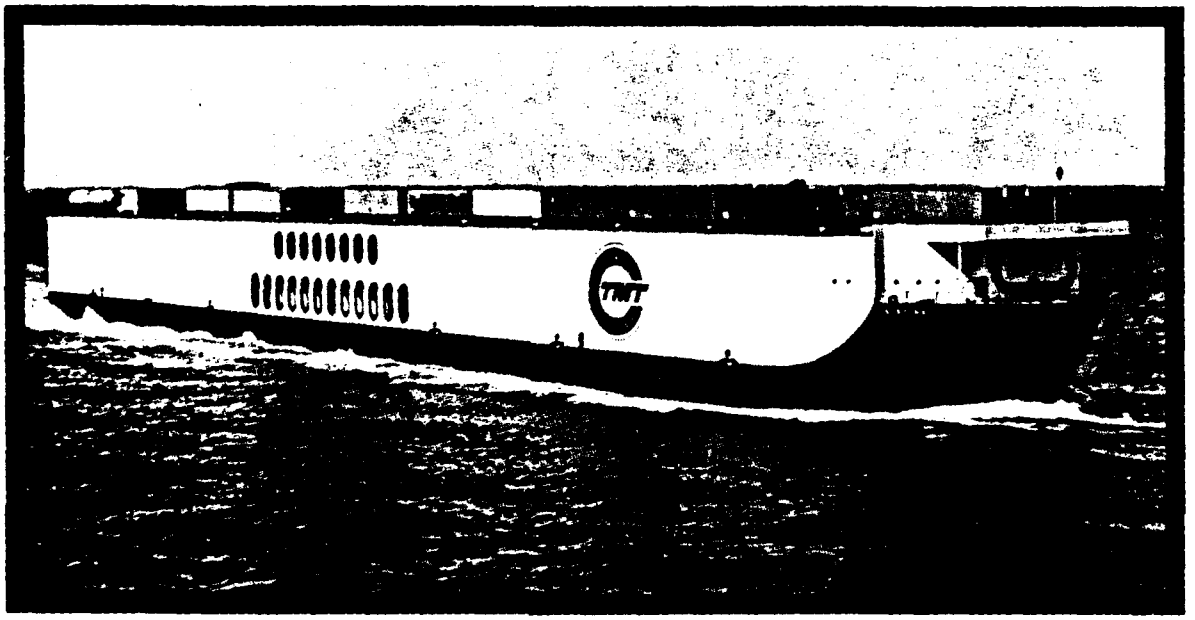
The expansive, flat decks of a barge provide the perfect platform for all types of RO/RO cargo, and the barges' shallow-draft design minimizes pitch and roll, providing greater transport stability. Trailers and other cargo ride smoothly and safely between ports.

TMT's new triple-deck barges, the largest in the world, were built to accommodate the rapid growth in Caribbean trade. Each mammoth barge measures 580x105 feet, is taller than a five-story building and is capable of carrying up to 374 forty-five- and forty-foot trailers.

Double-deck barges with individual capacities of 180 trailers continue to play an important role in TMT's overall service. Like the tri-deck barges, they provide stability at sea and can be discharged and loaded in a matter of hours.

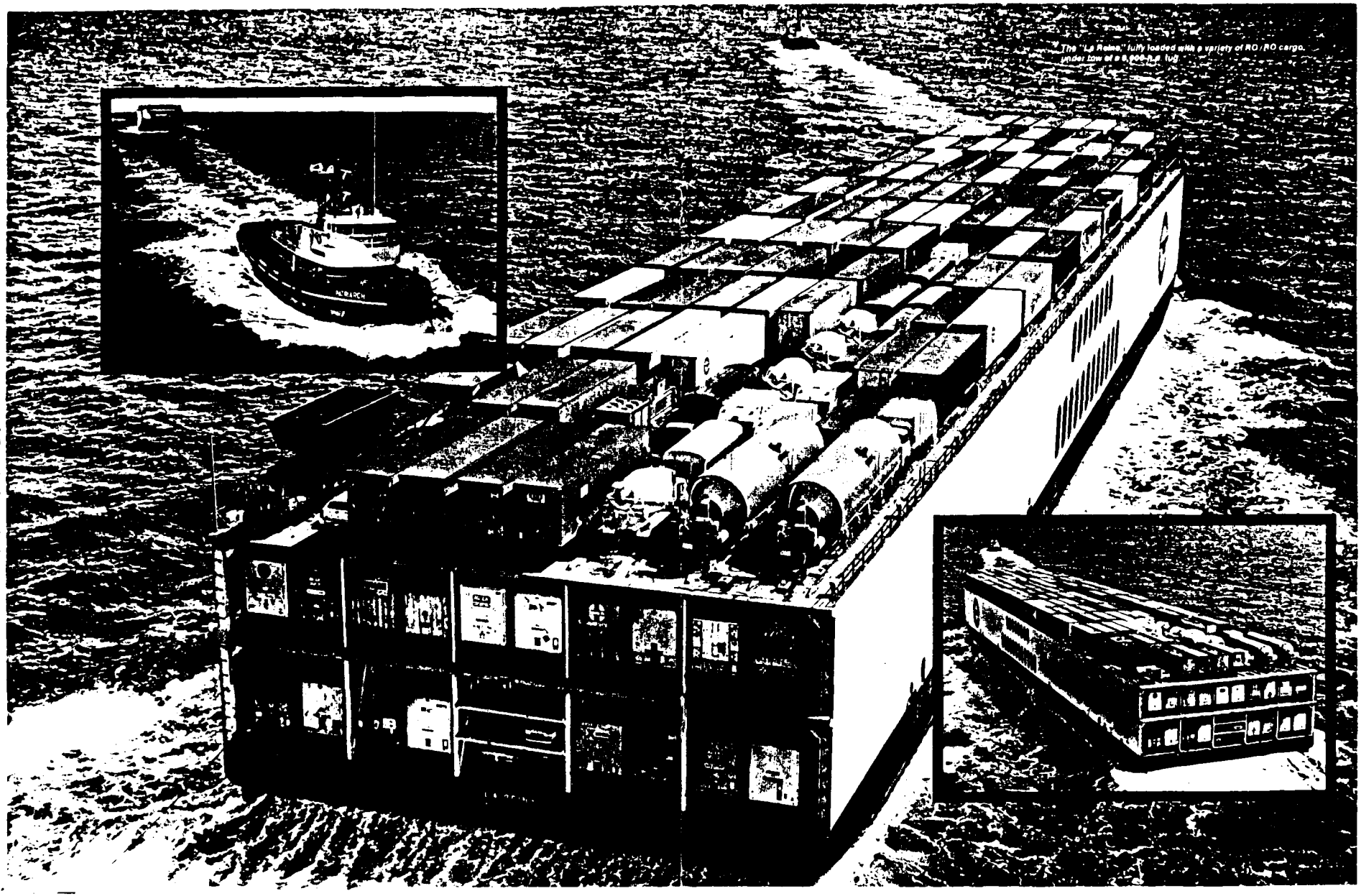
All TMT barges are towed by powerful 9,000-h.p., ocean-going tugs. TMT tugs are fully pilothouse controlled and equipped with the latest in navigational equipment.

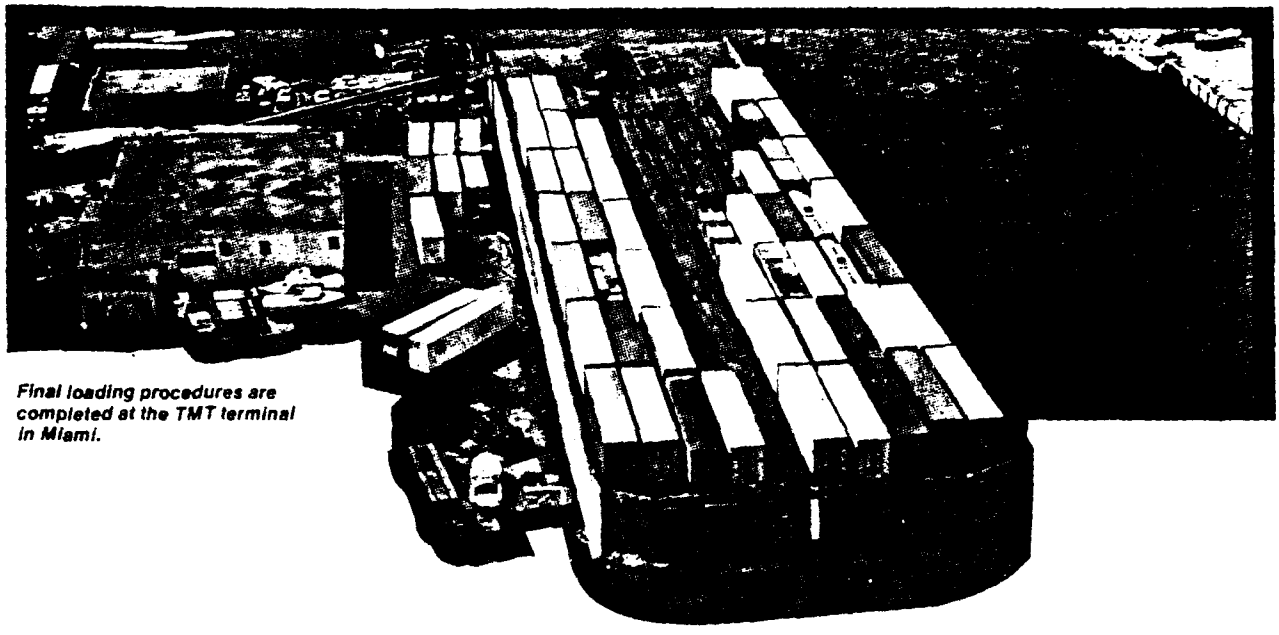




(Top) A cutaway drawing of a TMT triple-deck barge illustrates the trailer movement on all deck levels simultaneously.

(Bottom) The triple-deck barge's flat deck provides safe, easy transport for all types of RO/RO cargo and the shallow-draft design minimizes pitch and roll.





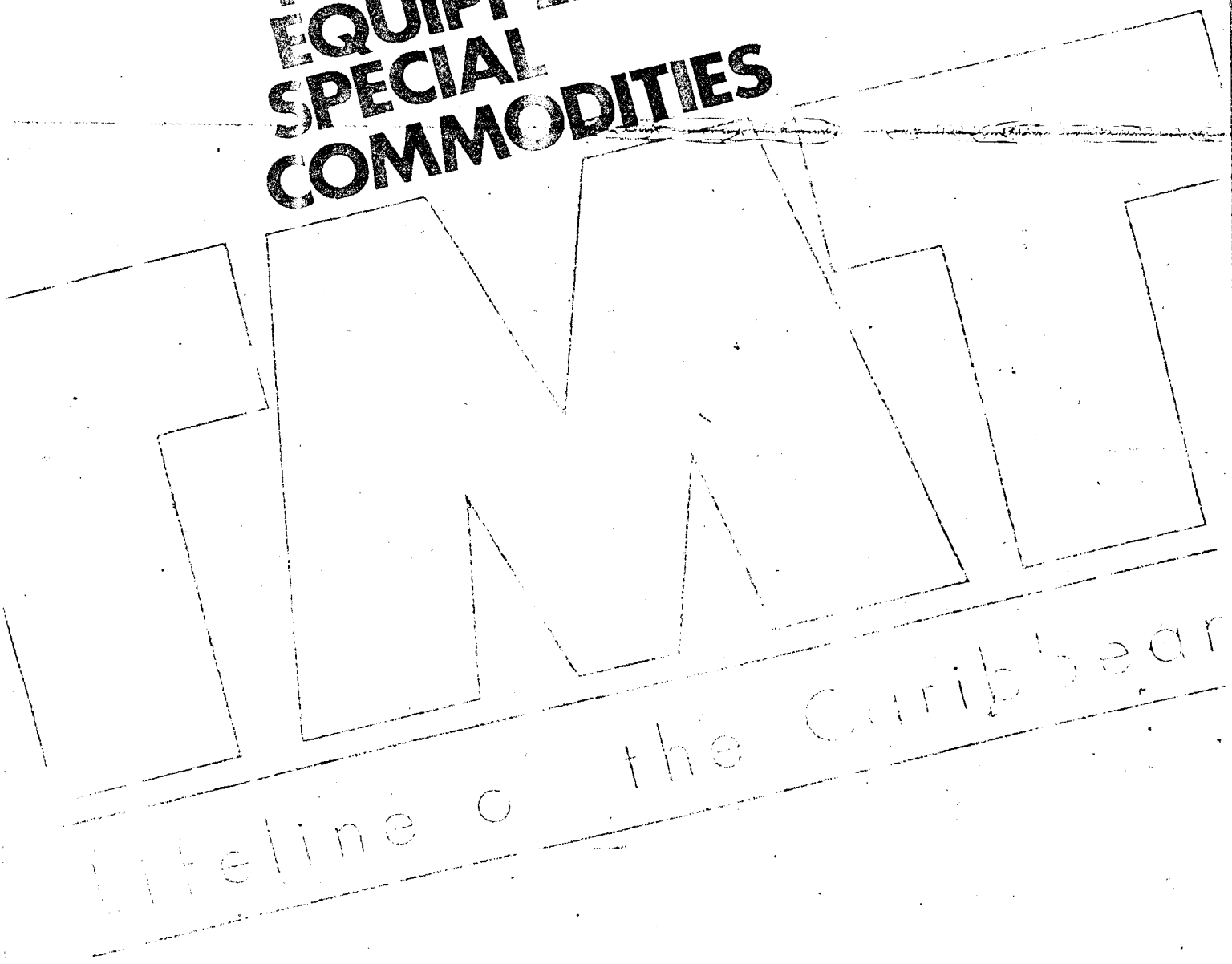
Final loading procedures are completed at the TMT terminal in Miami.

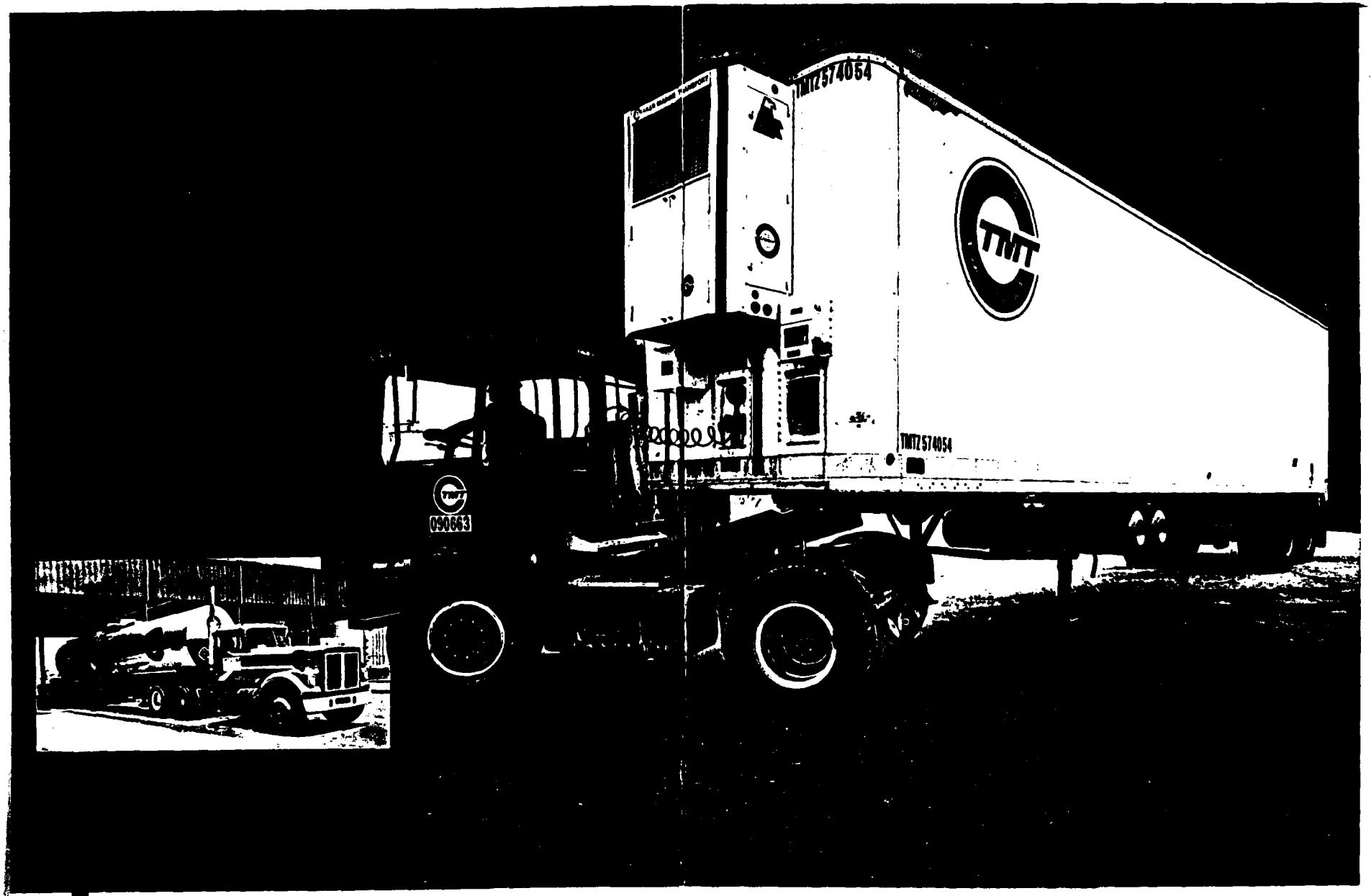
A TMT double-deck barge carrying cargo between Lake Charles, Louisiana, and San Juan.

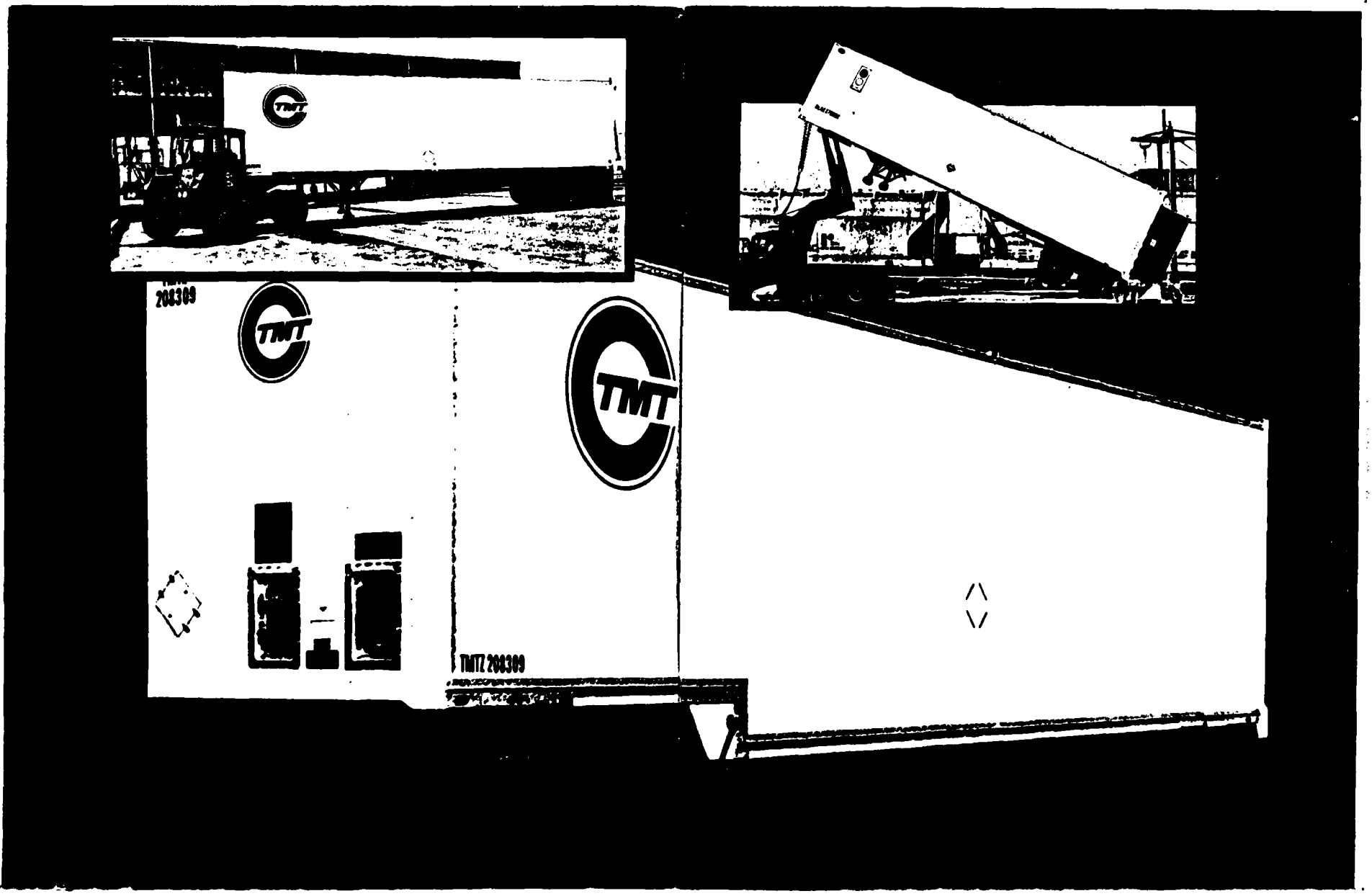
Each TMT barge is equipped with rub rails, a fifth-wheel device that automatically locks the front of the trailer in place, and chains that lash the back end of the trailer securely to the barge.



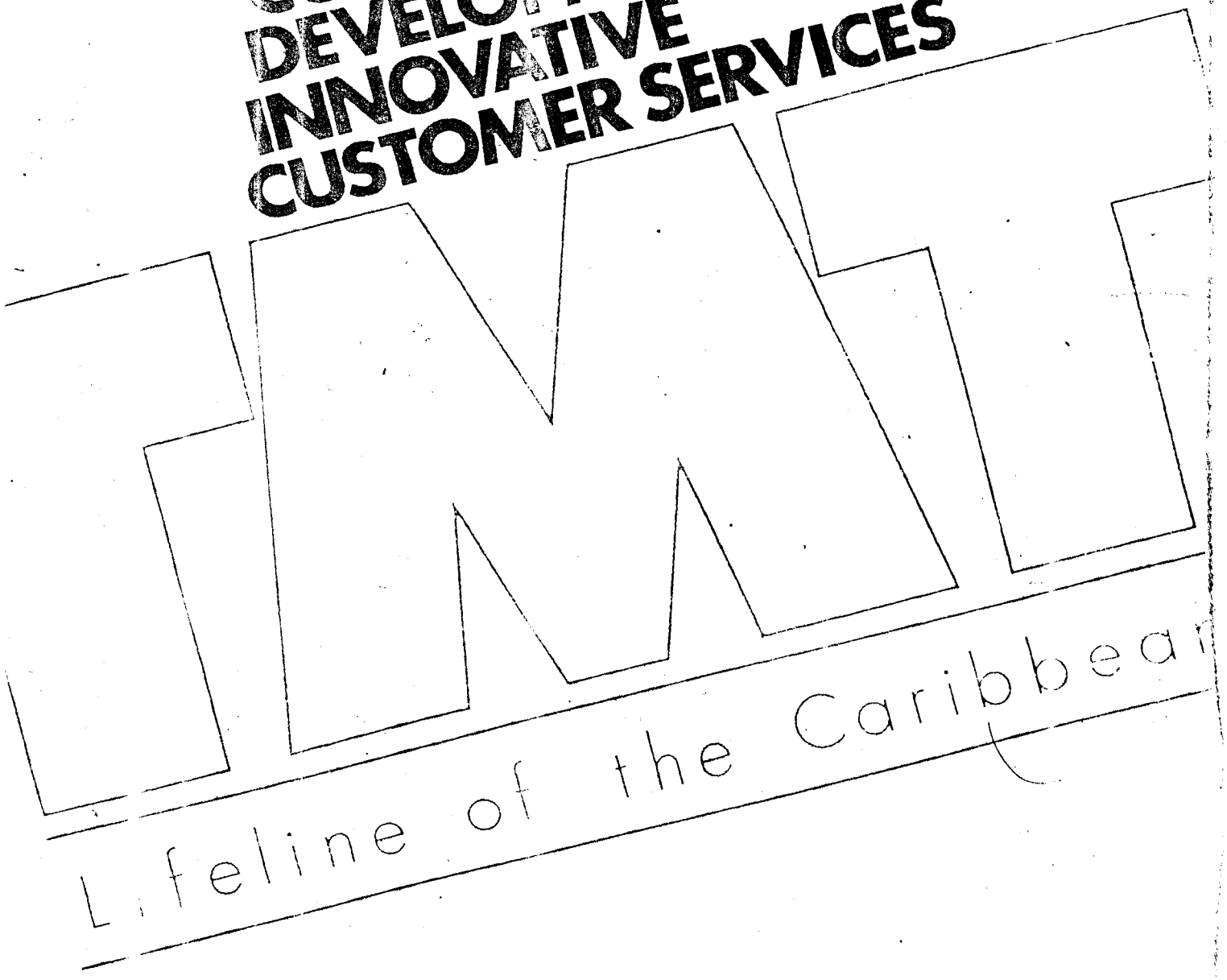
A MODERN FLEET OF TRAILERS EQUIPPED FOR SPECIAL COMMODITIES




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TMT
TMTZ574054
090683

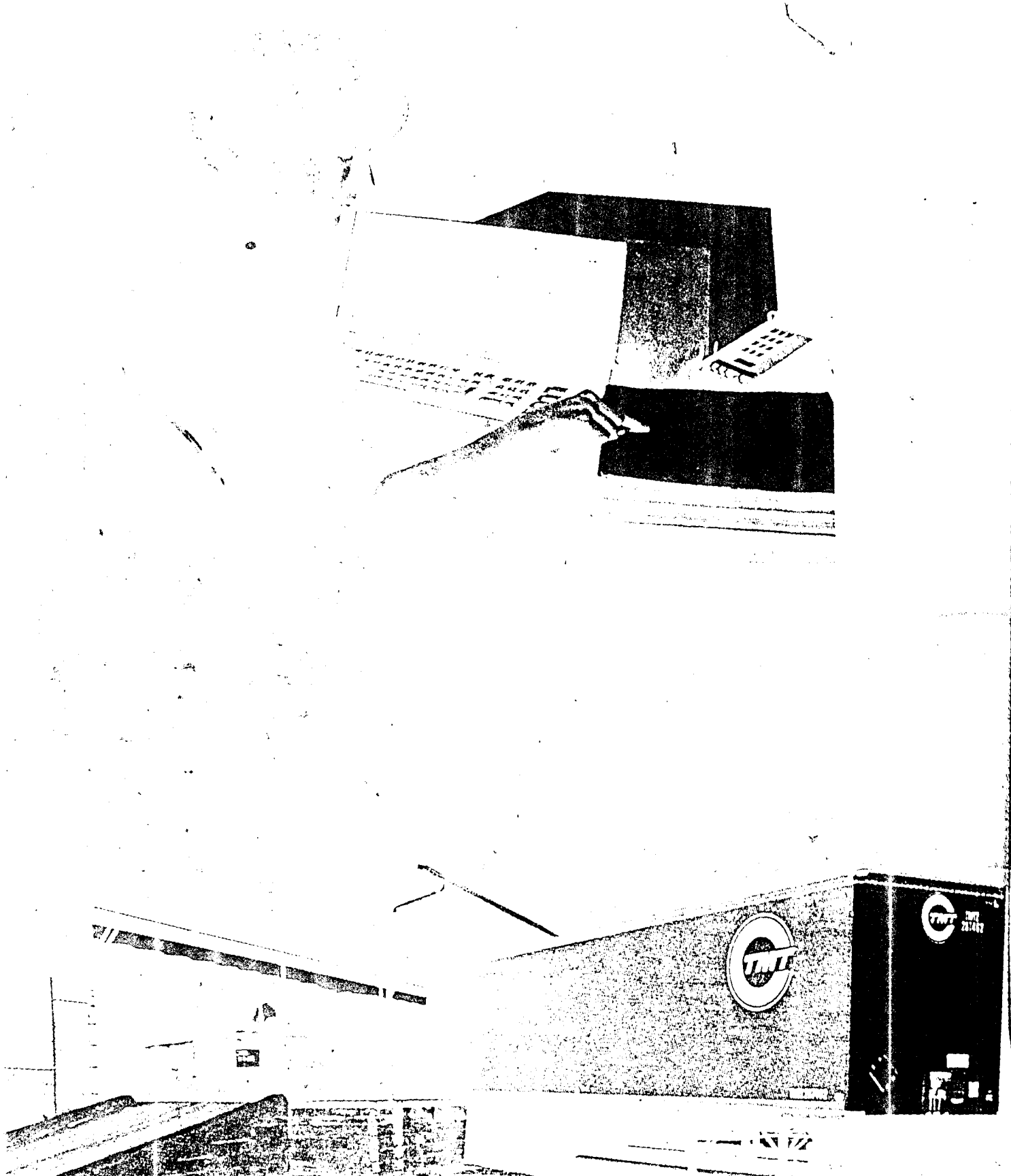

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TMT
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TMT 208309

CONTINUAL DEVELOPMENT OF INNOVATIVE CUSTOMER SERVICES

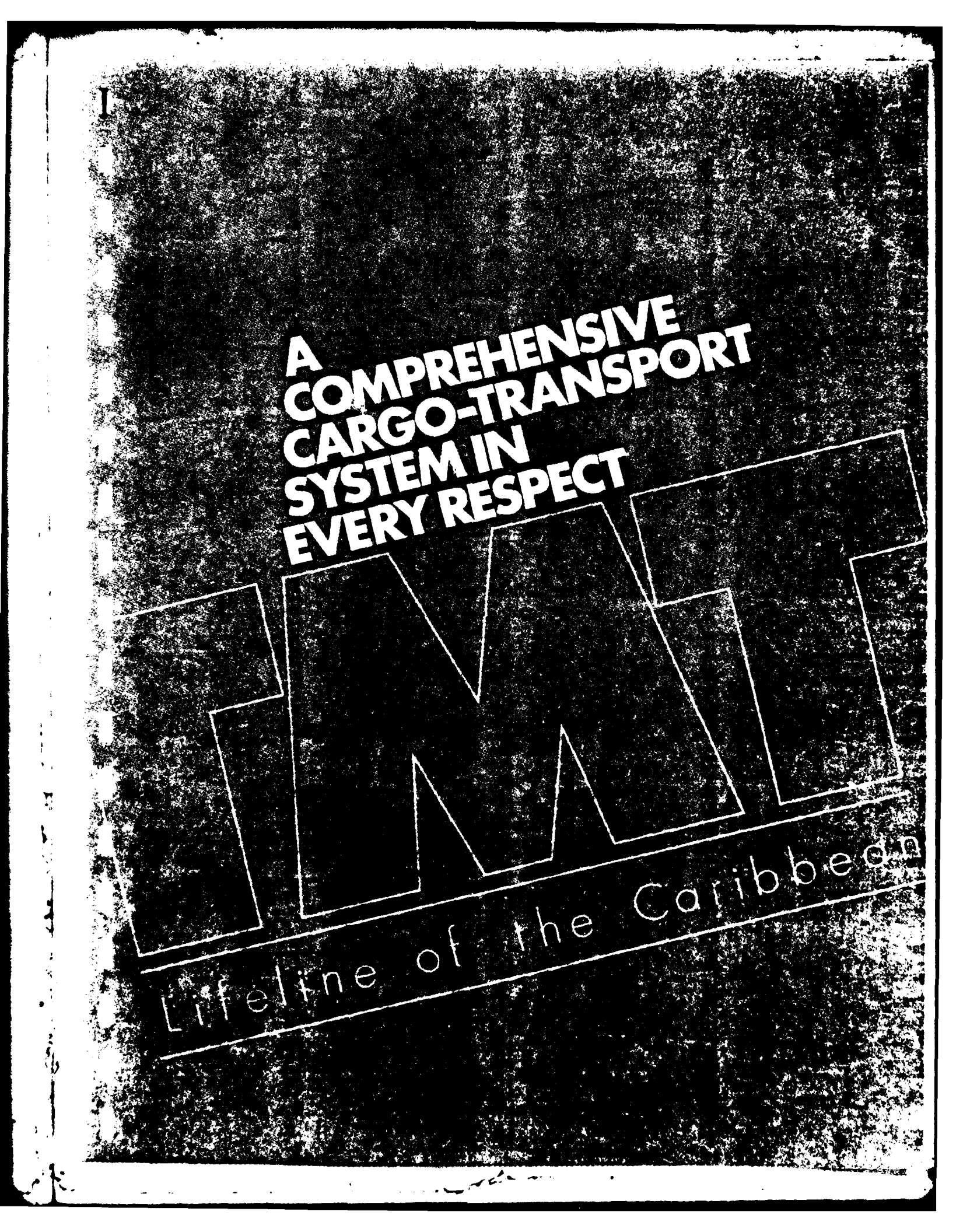




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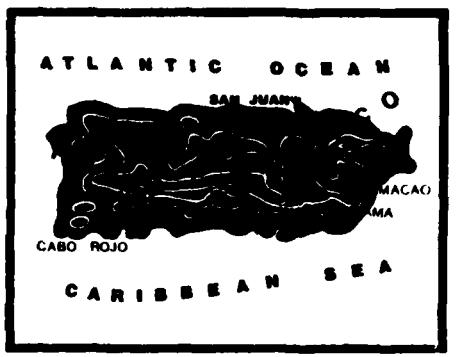
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A COMPREHENSIVE CARGO-TRANSPORT SYSTEM IN EVERY RESPECT
LMI
Lifeline of the Caribbean

TMT's reputation for innovation and dependability has been a result of our continuing effort to provide comprehensive service in cargo transportation. This has evolved into a tradition of designing and utilizing the most modern equipment, initiating new services, improving facilities and establishing additional ports as needed.

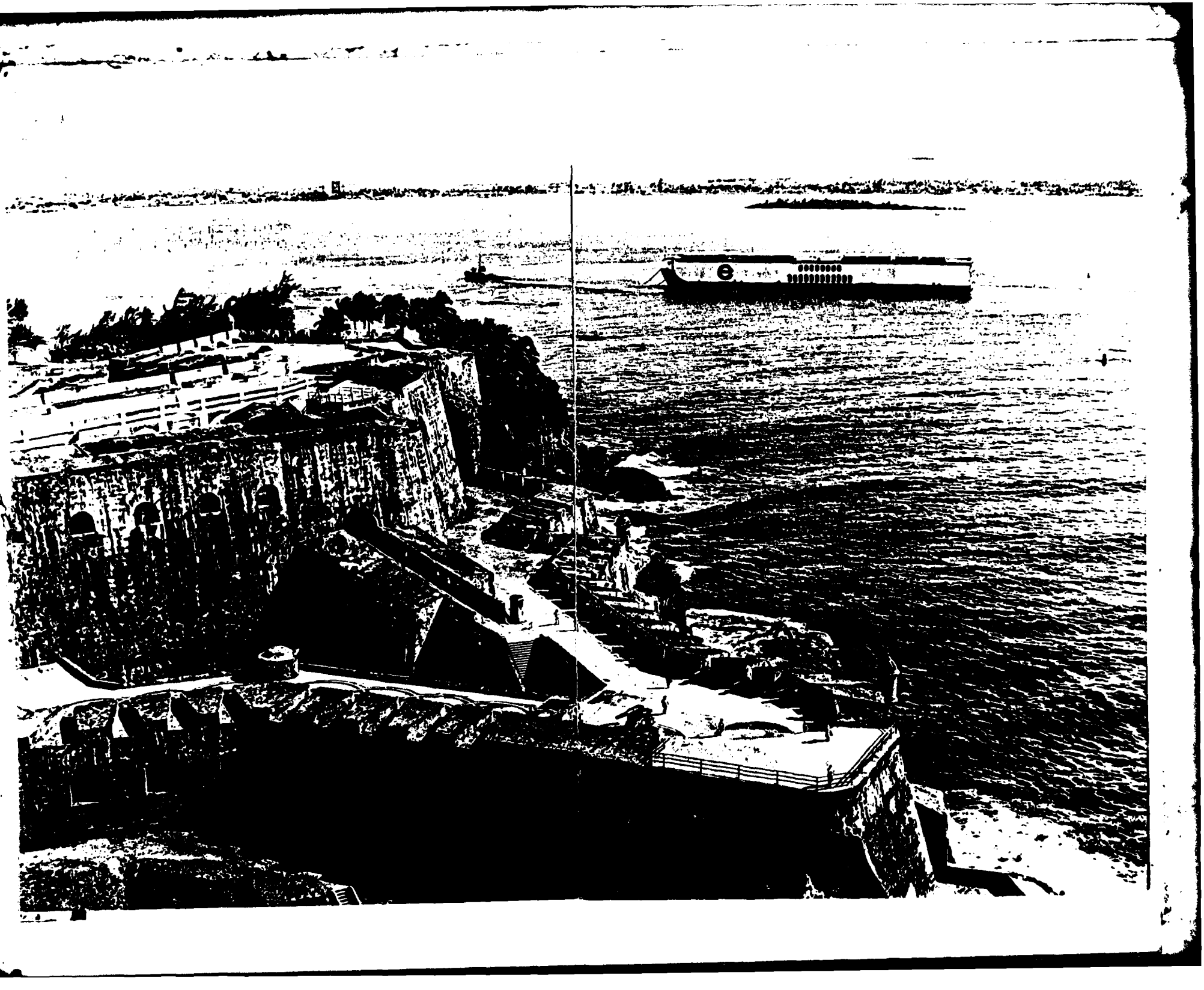
Currently Caribbean-bound cargo moves from points across the U.S., through one of the three stateside ports to San Juan, Puerto Rico, the hub of TMT's Caribbean service. In San Juan truck tractors pick up trailers for inland hauling throughout the islands, while trailers bound for other parts of the Caribbean are transported by TMT affiliates to the Virgin Islands, the Dominican Republic, and the Leeward and Windward Islands.

From point of origin to final destination, we're continually finding new ways to meet the increasing needs of Caribbean shippers.



Puerto Rico is both the industrial center of the Caribbean and the hub of TMT activities. From San Juan cargo is routed by TMT to destinations in the Dominican Republic, the U.S. Virgin Islands, and the Leeward and Windward Islands. Measuring 100 by 35 miles, Puerto Rico is the easternmost island of the Greater Antilles and the gateway to the Caribbean. For over four centuries its economy was based on two commodities, sugar and coffee, until the 1940's when an intensive industrialization program was begun. TMT, which introduced intermodal transportation in Puerto Rico in 1954, has kept pace with the island's burgeoning economy ever since.

TMT ocean-going barges provide regularly scheduled service between Puerto Rico and Jacksonville, Miami and Lake Charles.



TRAILER MARINE TRANSPORT CORPORATION

A CROWLEY COMPANY
P.O. BOX 2110 / 815 HAINES STREET / JACKSONVILLE, FL 32203

(904) 354-0352

MARKETING OFFICES:

ATLANTA, GA
(404) 939-4747

CHARLOTTE, NC
(704) 537-5933

CHICAGO, IL
(312) 828-0670

COLUMBUS, OH
(614) 436-6580

DALLAS, TX
(214) 688-0551

HOUSTON, TX
(713) 931-1100

JACKSONVILLE, FL
(904) 354-0352

LAKE CHARLES, LA
(318) 439-6147

LOS ANGELES, CA
(213) 435-4416

MIAMI, FL
(305) 672-1235

NEW YORK, NY
(212) 425-3986

PONCE/MAYAGUEZ, PR
(809) 843-6368

SAN FRANCISCO, CA
(415) 546-2387

SAN JUAN, PR
(809) 725-5600

ST. CROIX, VI
(809) 773-3119

ST. THOMAS, VI
(809) 774-2933

ST. LOUIS, MO
(314) 727-7878

AGENTS:

ANTIGUA, WI
2-1224 (ST. JOHN)

DOMINICA, BWI
2181 (ROSEAU)

GRENADA, BWI
2742 (ST. GEORGE)

GUADELOUPE, FWI
82-4341 (POINT-A-PITRE)

MARTINIQUE, FWI
71-0040 (FORT-DE-FRANCE)

MEXICO CITY, MX
(905) 514-5417

MONTSERRAT, BWI
2581 (PLYMOUTH)

ST. BARTHS, FWI
87-6033 (GUSTAVIA)

ST. KITTS, BWI
2631 (BASSETERRE)

ST. LUCIA, BWI
2811 (CASTRIES)

ST. MAARTEN, WI
3410 (PHILLIPSBURG)

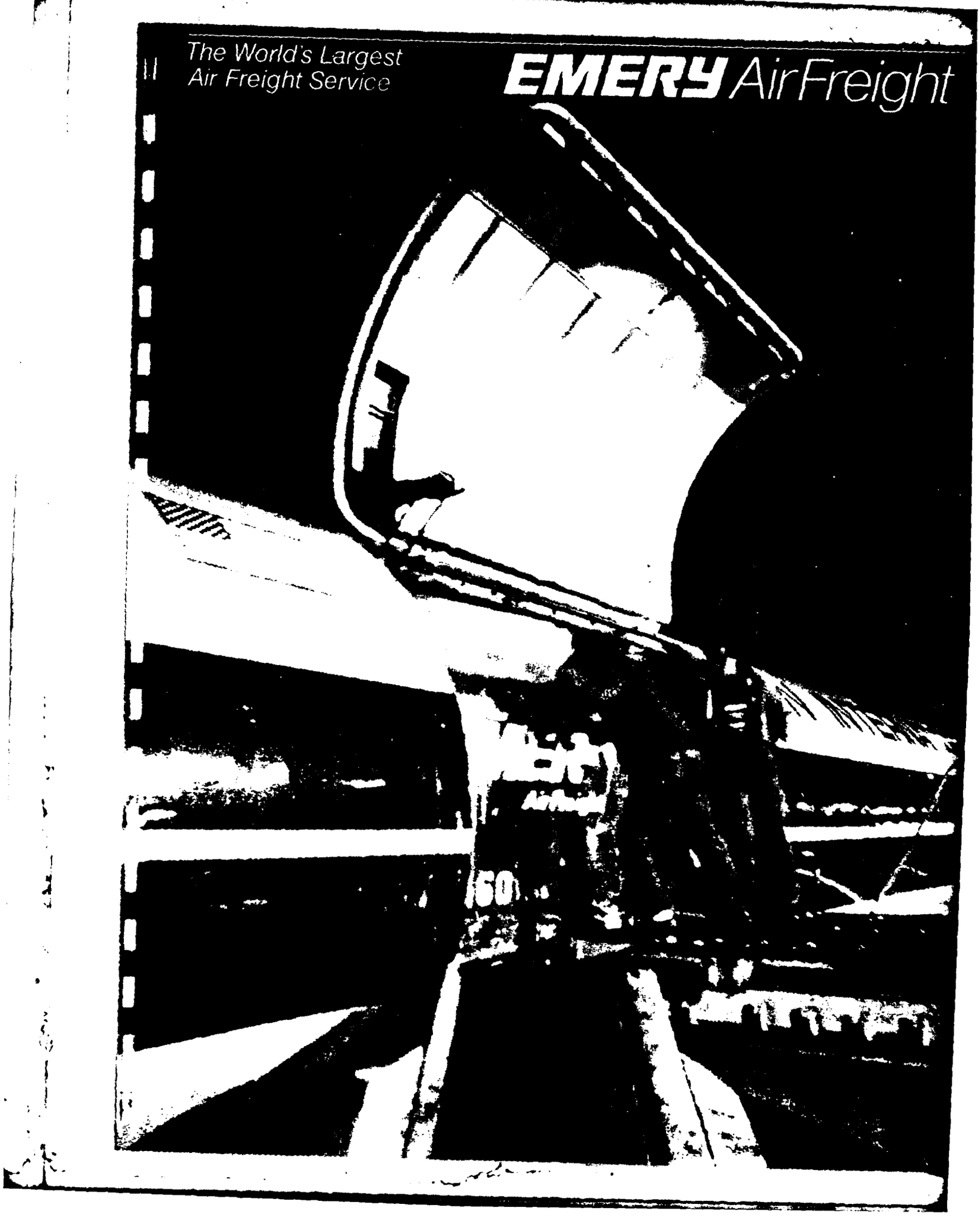
ST. VINCENT, BWI
61311 (GEORGETOWN)

SANTO DOMINGO, DR
(809) 565-6661



APPENDIX B

EMERY AIR FREIGHT SERVICES


The World's Largest
Air Freight Service
EMERY Air Freight

Emery Air Freight Puts You In Control.

I use Emery Air Freight because I can count on their regular pickups, deliveries *and* tracking capabilities on shipments I send or expect to receive. Since the computers we make are high ticket items, I need to know where they are and be sure they will arrive in perfect condition.

When we heard that Emery Air Freight flew a 19,000 pound piece of coal mining equipment 3,000 miles overnight to a remote part of Pennsylvania, we knew they wouldn't have any problems delivering our shipments of replacement parts for production lines all over the country.

We printers are always up against last-minute deadlines...and getting our brochures and promotion pieces to our clients' sales meetings and trade shows is always a last-minute rush. Without Emery's on-time air freight deliveries, all our hard work wouldn't be worth the paper it's printed on.



We make electrical panels, switches and circuit breakers—heavy-duty equipment that needs to be handled with kid gloves. Emery Air Freight takes care, and with their overnight deliveries all over the country, we get the kind of shipping control we count on to stay in business. Emery moves my freight as fast as they move my Express packages.

You Can Depend On Emery Air Freight's Total Services.



For dependable service, you can count on Emery

To more than 20,000 U.S. cities as well as points worldwide. With offices and agents at more than 190 U.S. airports; with over 5,000 Emery employees trained in all aspects of air shipping, with no restrictions to route or aircraft size, with trucks of every dimension, a worldwide computer tracking system that knows where your freight is, from pickup to delivery, with over 30 years and billions of pounds of experience; we have more going for you than any other air freight service. So, if your shipment is too big for a small package operation or too important to trust to a company with less experience, relax; we'll get it there for you.

It starts with your need for speed and reliability

At Emery, we appreciate your need for speed, and we've built a system of control to track your shipment from origin to destination. Control and reliability are a result of coordination—pickup and delivery timetables, dedicated people, and routing flexibility, as well as computer tracking. Emery's delivery system is designed to provide safe, reliable service overnight whenever possible.

Controlling air lift and ground handling—Our key to dependability and speed

Getting freight off the ground and into the air when we want to is one reason why Emery's shipments are delivered as promised. Flying at night with our own fleet of planes creates a minimum delay in take-off and landing, so we can meet your deadlines. We have aircraft dedicated to serve our customers' needs, so space reservations as well as departure and arrival times can be accurately planned. Emery's airport facilities improve our control and minimize ground handling time required to move your shipments to their destination.

Some extra muscle—Assurance for our customers

We have a network of Emery planes serving major cities in the U.S. We also schedule space on flights of every airline and reserve space on "off-line" commuter air services to supplement our access to more remote locations.





Some Of The Other Emery Services.

And, to insure that our service always meets customer expectations, we back up our aircraft with a "bench fleet", fully fueled and ready to go whenever they're needed.

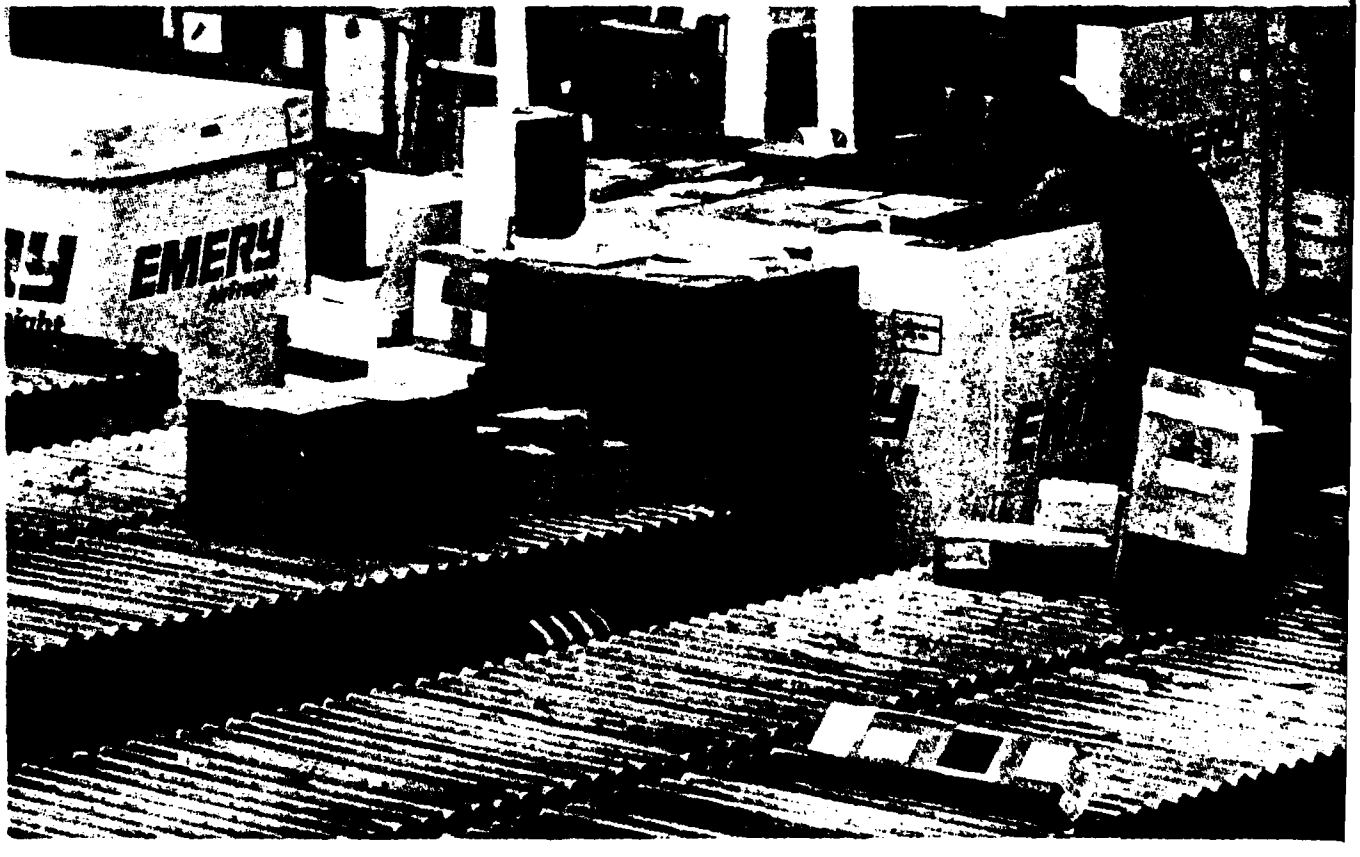
EMCON: Your Computer Control System
Each night we handle millions of pounds of shipments. Keeping track of it all is EMCON, Emery's Computer Control System, a dedicated shipment tracking and customer information service.

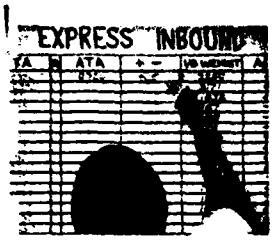
Information on the status of any shipment may be obtained promptly through EMCON by calling any Emery office. In most cases, we'll get the information you need while you're on the phone.

EMCON helps us deliver shipments for our customers all over the world who count on us for speed and reliability. Customers with deadlines that "can't be missed"... customers who rely on us to get their shipments delivered on time.

Emery Air Freight—
Any size, Any weight, Any where
As long as your shipment can fit on a truck or in a plane, we can deliver it. Anywhere in the world. We're a 24 hour-a-day business, with over 5,000 Emery employees specializing in all aspects of air freight transport. We spend all day being precise in our pickup and delivery because we work all night loading and flying. Your daytime freight is our nighttime business.

First Flight Service—
Delivery today without a moment's delay
No size or weight restrictions, your "same day" deadline will be met. Your package is picked up at your door by a specially dispatched vehicle which will go directly to the airport. There, it is put on the next available flight to your destination. Since advance information has been sent out to the destination office, a vehicle and driver will be waiting at the destination airport to deliver to the consignee. First Flight Service—for your very important packages.







Emery Express—
From here to there...overnight

For your smaller packages that weigh less than 70 pounds, overnight door-to-door delivery to more than 70,000 cities in the U.S. including Hawaii, Alaska and Canada.

Our express service to Europe provides 48 hour desk-to-desk delivery of non-dutiable business documents under 70 lbs.

International Air Freight—
We go the distance for you

Emery has 50 offices in Europe and the Pacific; plus 95 exclusive agents, doing business at 130 international airports in 49 countries, including Canada. You get Emery's dependability, efficiency and economy worldwide.

Air Procurement Service—
Inbound coordination and control

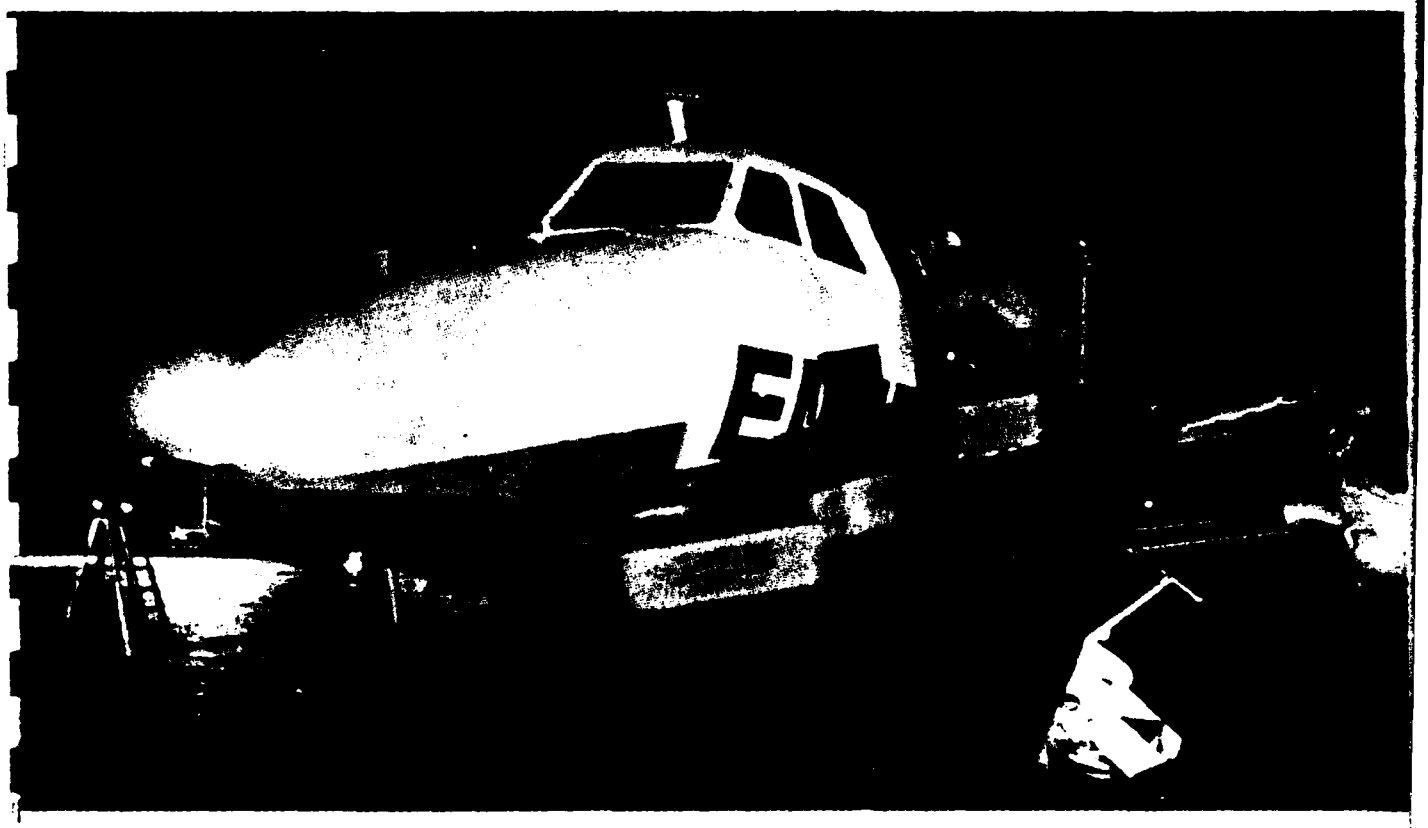
Pioneered by Emery, air procurement service extends your purchasing control right to your supplier's plant. Emery checks your supplier in advance to make certain pick-up will be ready as promised. There is no charge for this convenience, which is really like adding a person to your own staff for follow-up with vendors.

Assembly Service—
Consolidating to save you money

All shipments originating in one area are consolidated and speeded to you as one, low-cost shipment, giving you improved inbound shipment control at a savings in transportation costs.

Emery Distribution Service—
When distribution requirements demand special attention

Emery will store your shipments at our warehouses, then sort and forward according to your specific distribution plans. Parts or products will be pre-positioned at strategic locations for redistribution on a planned or as-needed basis.







Emery Air Courier Service—
We take personal responsibility

A bonded courier will take the shipment from your hands and carry it by the fastest direct flights and personally deliver it. If the consignee is on the move, our courier will track him down. If the weather socks in, or a flight is cancelled, our courier will keep moving by the fastest available means. As soon as the package is delivered, you will be notified by telephone and written confirmation of delivery is mailed immediately.

Emery Air Charter Service—
Sometimes you need your very own plane

For very large or urgent shipments, the convenience and security of single-handling, point-to-point transportation; quicker transit times to dovetail precisely with your critical schedule; easier documentation and quicker customs clearance on exports or imports. For any charter; from a Skyvan to a Boeing 747-F, Emery works to your advantage and savings.

Emery Ocean Freight—
We deliver in ship shape

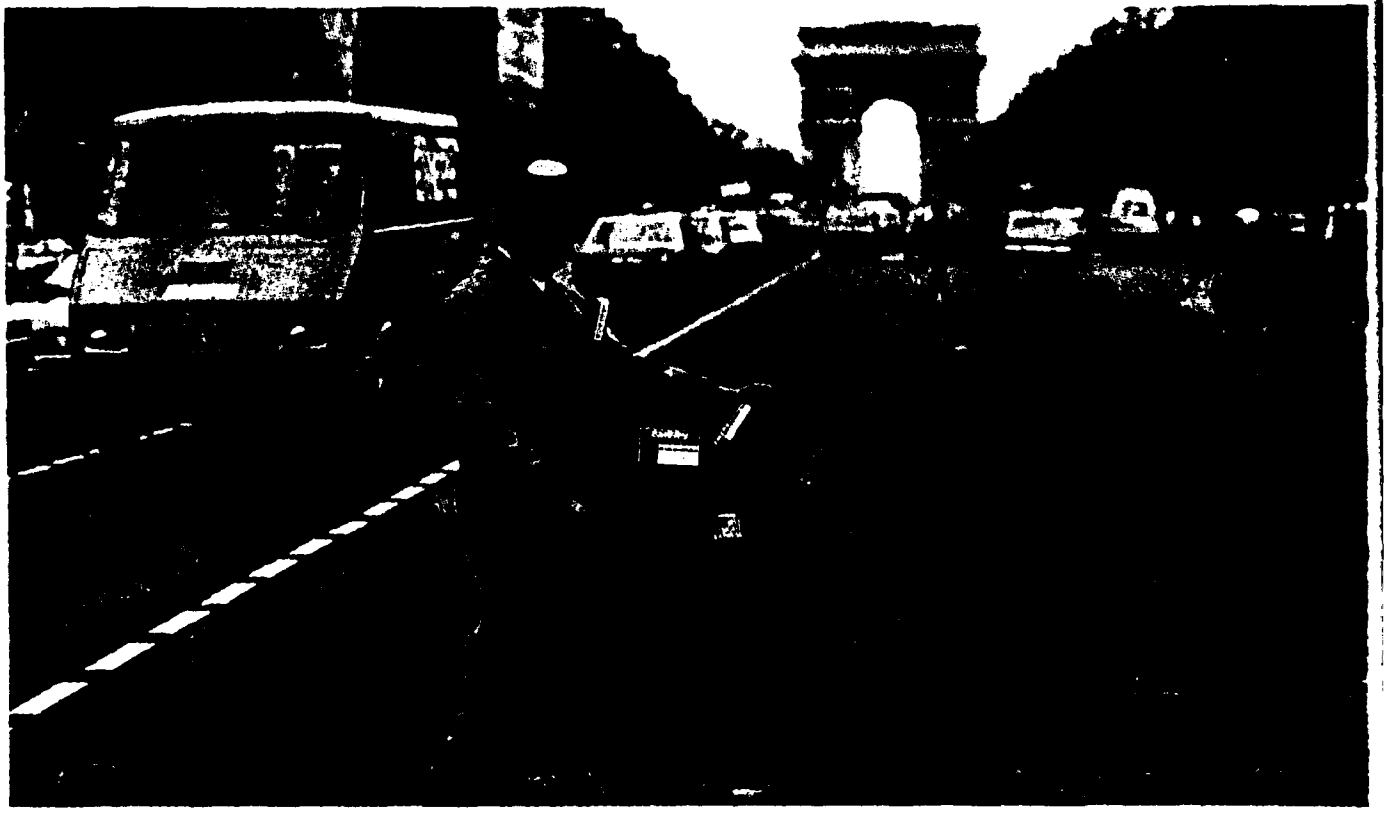
Emery strikes the perfect balance between urgency and economy with our own regularly scheduled containers on ocean freighters and our car-loading services for LCL rail transport to key ports.

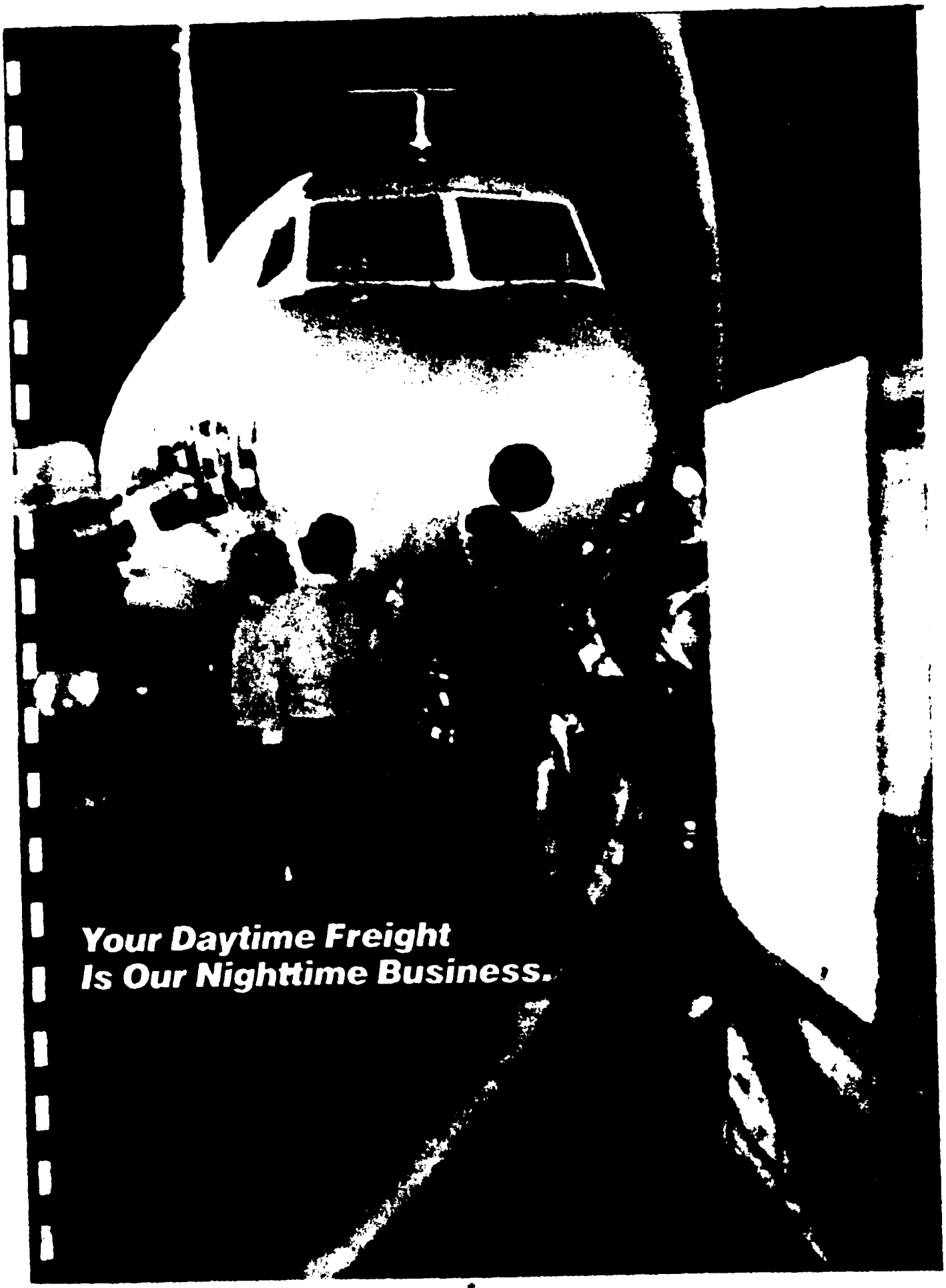
Emery Customs Brokers—
Our own people handle it all the way

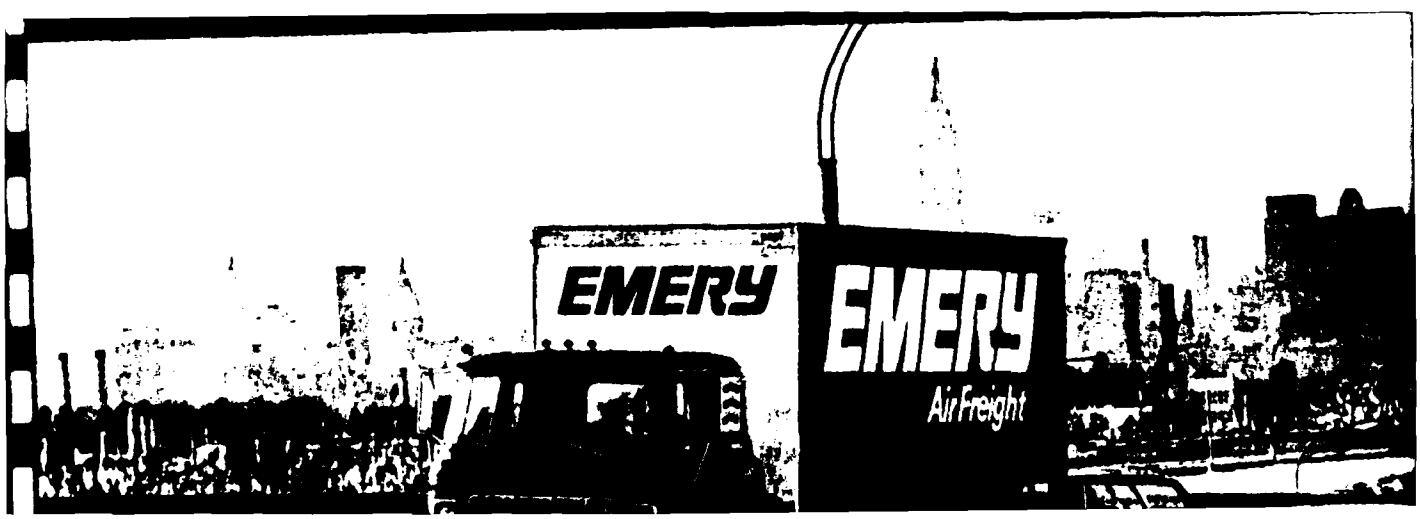
Emery picks up the freight at origin, checks or prepares international documents and moves freight and documents to destination. There are no delays in notifying brokers or shuttling valuable documents around the airport, because Emery customs brokers clear the freight. Emery's one-company accountability handles your shipment all the way.

Restricted Items

Emery personnel are well-trained and experienced in handling restricted items for transport.



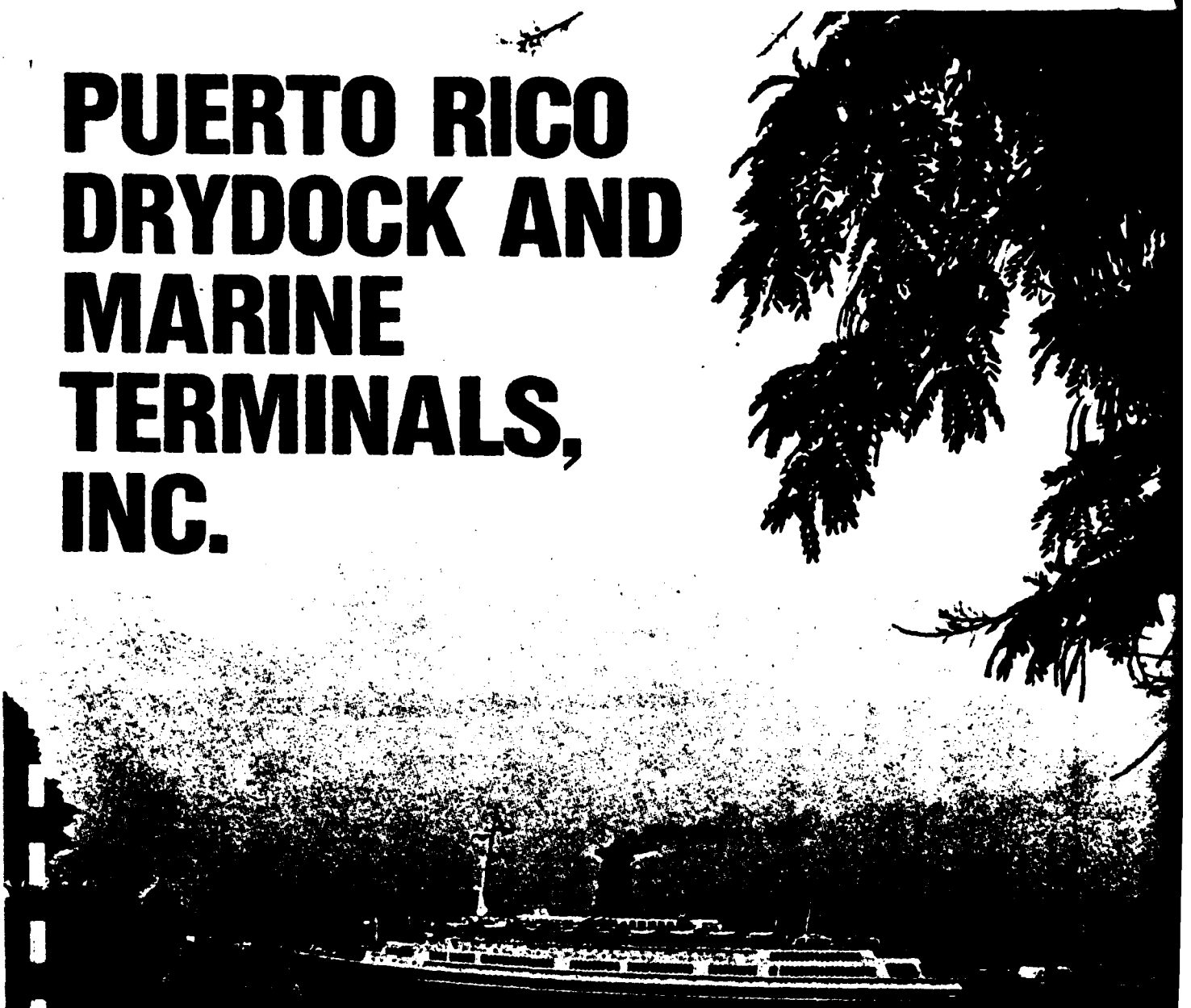

Your Daytime Freight
Is Our Nighttime Business.


EMERY
EMERY
Air Freight

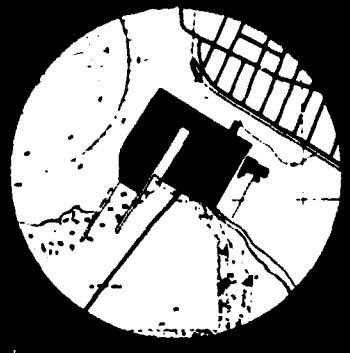
APPENDIX C

SAN JUAN, PUERTO RICO
SERVICES AND CAPABILITIES

PUERTO RICO DRYDOCK AND MARINE TERMINALS, INC.



AT THE CROSSROADS FOR GREATER ECONOMY



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AMERICAN

ship repair service

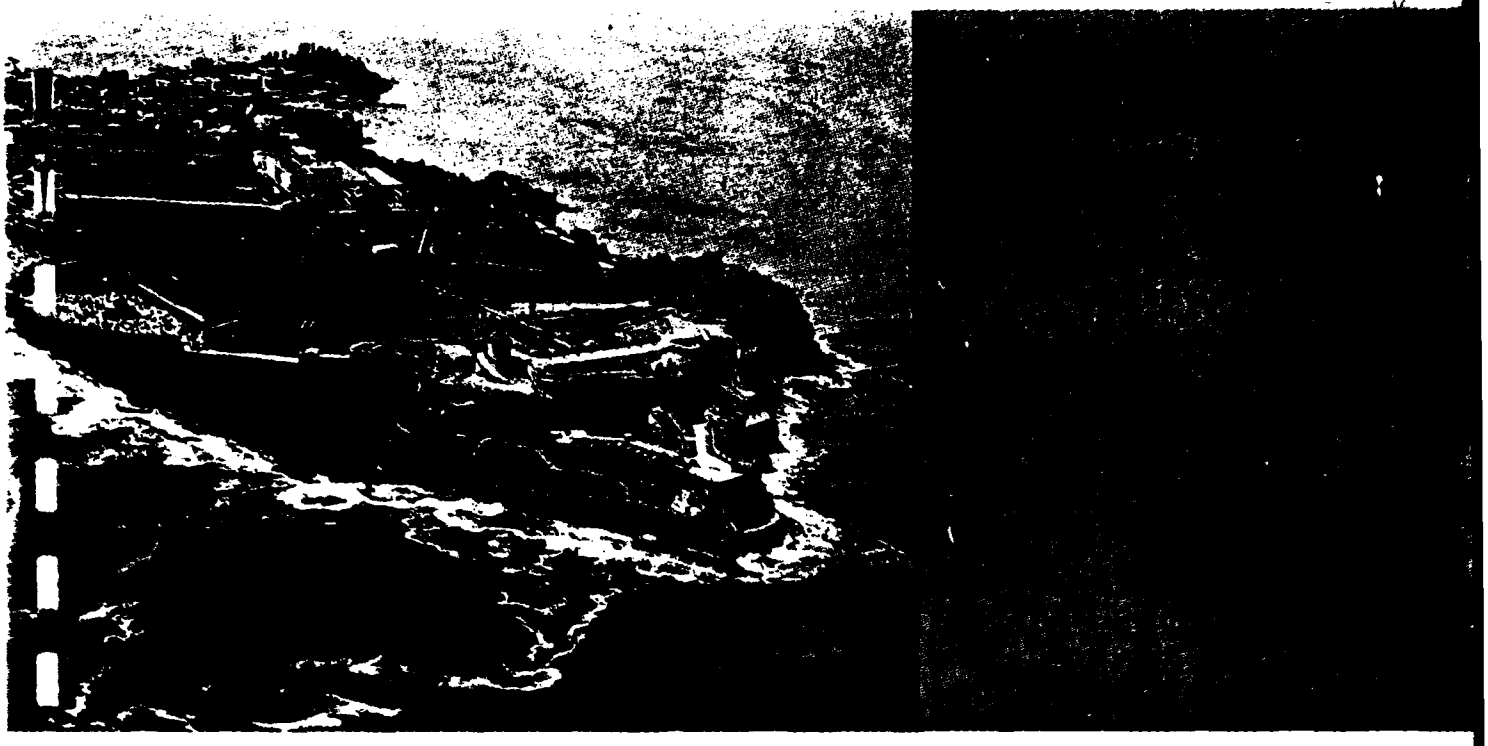
conveniently

located at

SAN JUAN • PUERTO RICO

DISTANCES FROM PRINCIPAL PORTS

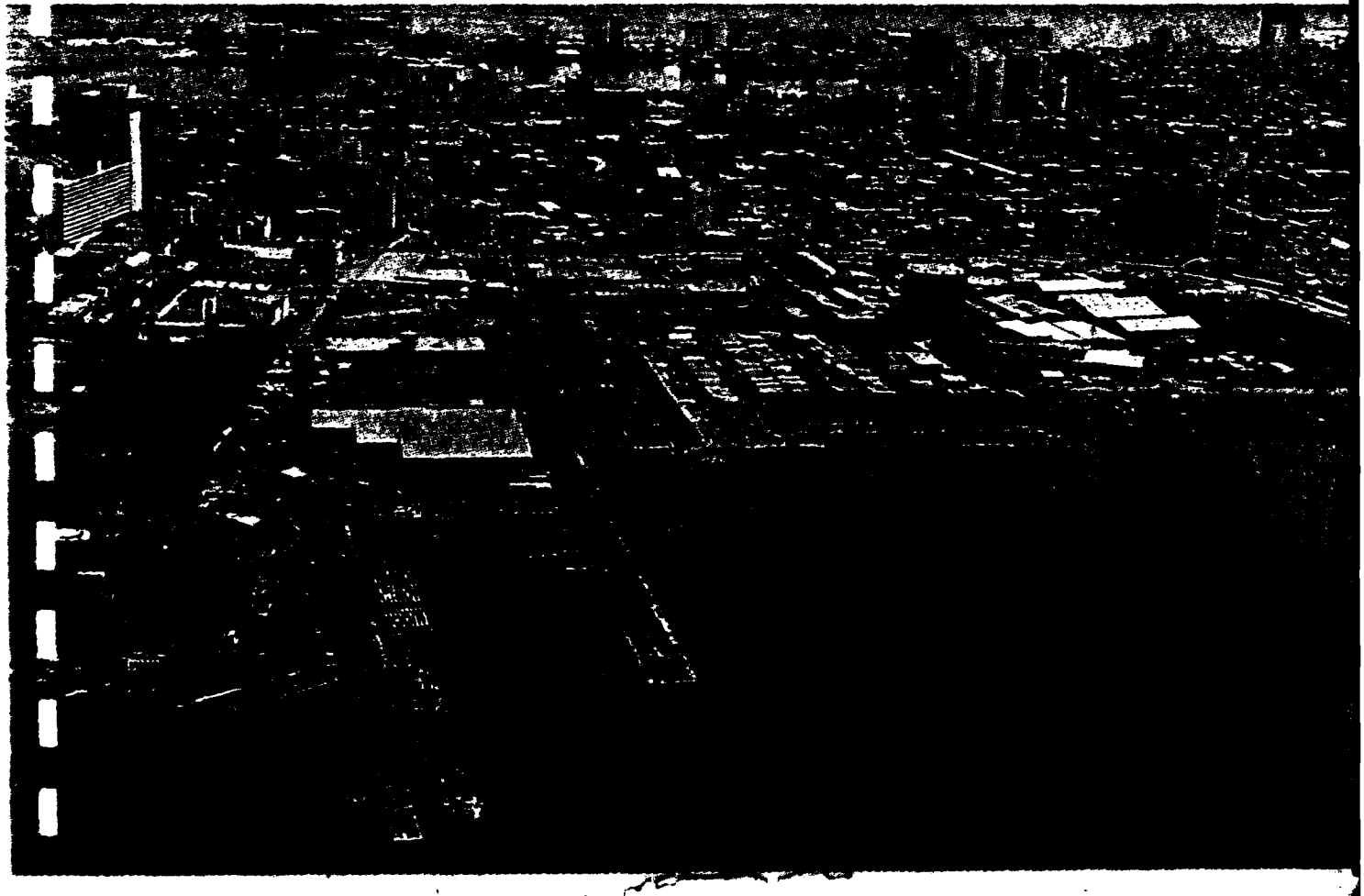
	Miles
Aruba	471
Baltimore	1374
Barranquilla, Colombia	706
Belem, Brazil	3390
British Guiana	874
Buenos Aires, Argentina	4753
Caripito, Venezuela	541
Colon, Panama C.Z.	993
Curacao	486
Gibraltar	3338
Guanta, Venezuela	590
Halifax	1580
Jacksonville, Florida	1121
La Guaira, Venezuela	506
Maracaibo, Venezuela	693
Miami, Florida	960
Mobile, Alabama	1484
Montreal	2471
New Orleans	1534
New York	1399
Norfolk	1252
Panama, Panama C.Z.	1036
Philadelphia	1395
Portland, Maine	1531
Puerto Cabello, Venezuela	541
Puerto Sucre, Venezuela	558
Rio de Janeiro	3652
Trinidad	573



PUERTO RICO DRYDOCK AND MARINE TERMINALS, INC.

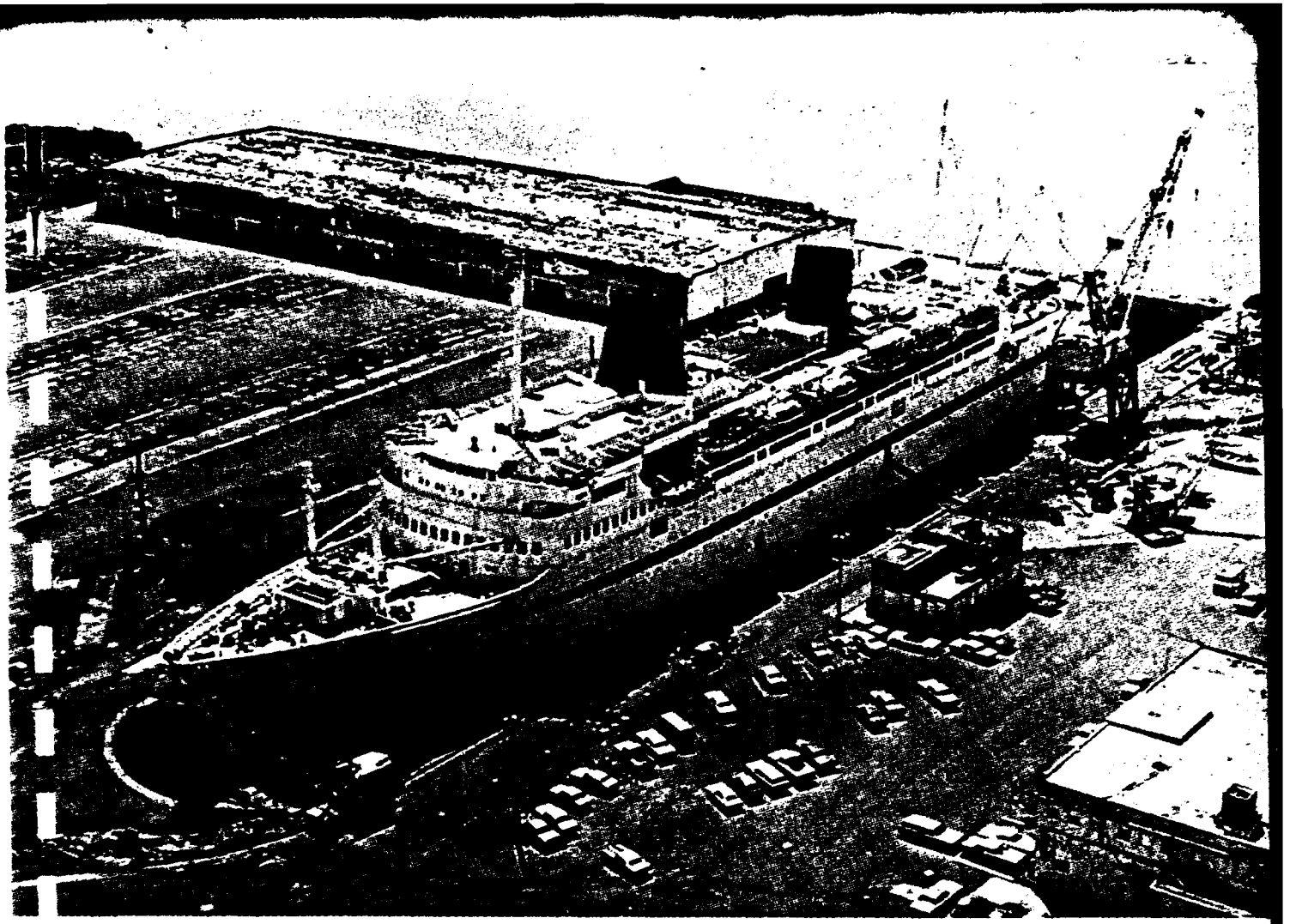
(Formerly a U.S. Naval Drydock & Repair Facility)

The Drydock and Repair Facilities are controlled jointly by the Ferre's and the Abarca's, two of the foremost industrialists on the Island, whose families have been in business for over 100 years.









PUERTO RICO DRYDOCK AND TERMINALS, INC.

- Centrally located for Voyage Repairs enroute.
- Annual repairs accomplished expertly and economically.
- A large stock of steel of all types, fittings, pipes and parts always on hand.

PLUS THESE PORT FACILITIES:

1. **PILOTAGE**

 Compulsory: foreign and U.S. vessel not having on board officer licensed as pilot of Puerto Rico. Day and night services.

2. **U.S. PUBLIC HEALTH SERVICE**

 Services sunrise to sunset.

3. **IMMIGRATION SERVICE**

 8 A.M. to 12 M. and 1 to 5 P.M. (Free). Overtime hours at Standard Government rate.

4. **U.S. CUSTOMS SERVICE**

 American Flag Vessels - Free.
 Foreign Flag Vessels: 8 A.M. to 12 M. and 1 to 5 P.M., free. Overtime hours charged at Standard Government rate.

5. **HARBOR DUES**

 Standard rates.

6. **TONNAGE TAX**

 U.S. Tonnage Tax and exemptions apply in Puerto Rico.

7. **MOORING CHARGE**

 Standard rate.

8. Only if discharging or loading.

9. **LAUNCH SERVICE**

 Several diesel launch available.

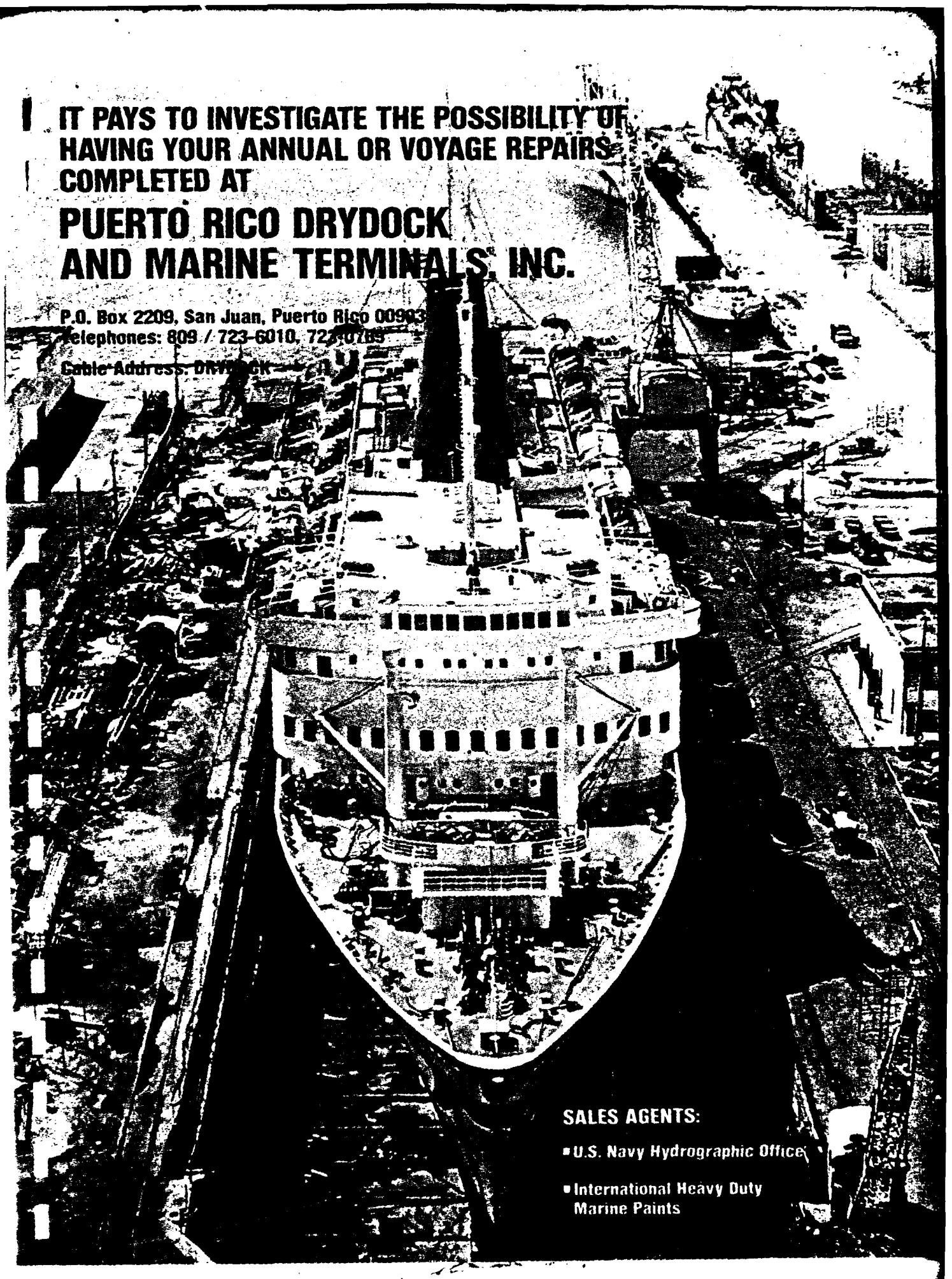
10. **TUG BOAT SERVICE**

11. **CLASSIFICATION SOCIETIES REPRESENTED IN PUERTO RICO**

 American Bureau of Shipping • Lloyd's Register of Shipping • Det Norske Veritas • Germanischer Lloyd • Registro Italiano Navale Japanese Marine Corporation • China Register of Shipping • Korean Register of Shipping Panama Register of Shipping, Inc.

12. **UNDERWRITERS REPRESENTATIVES**

 Salvage Society London
 Scandinavian Marine Claims Office, Inc.
 Scanamerican Claims Agency, Inc.


IT PAYS TO INVESTIGATE THE POSSIBILITY OF HAVING YOUR ANNUAL OR VOYAGE REPAIRS COMPLETED AT
PUERTO RICO DRYDOCK AND MARINE TERMINALS, INC.
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Telephones: 809 / 723-6010, 723-0785
Cable Address: DRYDOCK
SALES AGENTS:
U.S. Navy Hydrographic Office
International Heavy Duty Marine Paints

APPENDIX D

MARTINIQUE PORT INFORMATION EXTRACTS

(deleted from final report)

APPENDIX E

LAS PALMAS, GRAN CANARIA, SPAIN
PORT INFORMATION EXTRACTS

A surcharge of 100% applied to services rendered at night, also at night on Sundays or holidays.

A surcharge of 50% applied to services rendered on Sundays and holidays during the day. *Plus* surcharge of 10% for services of V.H.F. Station.

Airport—Gando, 5 km.

LAS PALMAS, Grand Canary

Lat. 28° 7' N; long. 15° 27' W. Free port (known as Puerto de La Luz).

Authority—Junta del Puerto de La Luz y Las Palmas. Postal and telegraphic address of Port Commandant: Comandancia de Marina, Las Palmas.

Accommodation—Good anchorage in the roads, 35 ft. plus—sandy bottom. Mean tidal range, 5 to 6 ft. Harbour has four quays, the outer or east quay (Generalissimo Franco) being 2,000 m. long, running N. and S. and showing revolving green light from S. extremity. This quay forms the breakwater and is used for bunkering and supplying fresh water and for discharge of oil. Of its 11 m. width, 3 m. encases double tiers of oil pipelines and water line. Depth alongside, 10 to 12.5 m. Well supplied with bollards and fenders; vessels of any size can safely berth, discharge or load cargo while bunkering.

From N. end of the Gen. Franco, running E. to W. is the mole Primo de Rivera, 285 m., d. alongside 10 m. plus; used as cargo and fruit mole; fuel and water lines have been installed.

From the E. end of this mole, running N. and S., is the La Luz Mole, 550 m., width 100 m., draft 8 to 10.5 m. alongside; cargo, fruit and passengers handled; fuel and water lines have been installed. Both Primo de Rivera and La Luz quays have covered cargo sheds. On the La Luz mole there is a cold store, Docks Frigoríficos De Canarias, S.A. 'Frigodocks' which has a capacity of 22,000 cu. m. divided into 25 chambers situated on three floors. The grain silo has a capacity of 32,338 metric tons and a pneumatic installation for discharge from vessels at 200 metric tons/hr. It has installations for water and oil supply. These three moles all have telephone communications from vessels to the shore. Running parallel to La Luz mole and 300 m. further W., the Castillo Mole (previously known as the Fishing mole) is 425 m. long, 100 m. wide, draft alongside 2–8 m. There are three cold stores on this mole: Frigoríficos Hispano Suizos, S.A. 'Frisu' 1, with a capacity of 5,000 tons; 'Frisu' 2, also with 5,000 tons capacity. Frigoríficos Canarios, S.A. 'Frigocan' has a capacity of 4,500 tons. Fishing boats berth along the W. side and vessels with general cargo on the E. side. The rest of the area of the mole (uncovered) is used for open storage. Santa Catalina mole, length 875 m., width 20 m., draft alongside 2 to 8 m., is now used principally for trawlers or small vessels. At each entrance to the Generalissimo Franco, Primo de Rivera and La Luz moles there is a weighing machine (30 tons). There is another with similar capacity on the Castillo mole and one of 20 tons on the Santa Catalina mole. At present vessels of more than 11 m. draft can berth only along 300 m. at the S. end of the Generalissimo mole.

Heavy cranes: Floating crane of 70-tons. Mobile cranes: 15 mobile cranes of 4 tons, two of 9 tons, two of 10 tons, one of 12 tons, one of 16 tons, three of 20 tons, one of 30 tons, two of 40 tons, and one of 70 tons.

Arguineguin Bay: 64 kilometres from Las Palmas on the Southern Tip of Grand Canary Island. The cement factory has a mole 200 m. long with draft of 8 m., diminishing to 5.3 m. at landward end. Discharge is effected by a shore crane and grab. Rate of discharge, 2,500 tons in 24 hours. Own resident pilot. Lights: Factory lights. Berthing in daylight only.

Development—Lengthening of new outer breakwater. Revision of port limits.

Bunkers—(By day and night)—Shell Cory (BP) Texas, Esso, CEPSA. Due to negligible demand for coal bunkers this trade has virtually ceased to exist, although reduced stocks are maintained. Fuel and diesel oil available at max. shore rate up to 1,000 tons/hr.

Shiprepairs—All repairs may be effected afloat (hull, machinery, electrical, etc.), including underwater cleaning and/or repairs by professional divers and frogmen. There are six slipways for vessels up to 1,000 tons displacement; one slipway for vessels up to 500 tons displacement; one slipway for vessels up to 3,500 tons displacement; and one floating dock accommodating vessels up to 5,000 tons displacement.

Charges—

Entrance and stay in Port. Port area is divided into two Zones.

Zone I is the sea space enclosed by the new outer breakwater, an imaginary line from the S. end thereof to the mouth of the Barranco de Guiniguada and the line of the coast.

Zone II is that part of the sea that is utilised for the anchoring of vessels outside the port between the coast and an imaginary line from El Roque or Bajo del Palo (off the Punta del Nido, La Isleta) towards the Punta de Melenara, until it meets an East/West line coinciding with the parallel, which passes through the Cathedral at its Southern limit. The Western limit is Zone I and the coast.

The extension of the port limits will effect Harbour dues and compulsory Pilotage Charges.

	Coastal Trade Ptas.	*Exterior* Ptas.
Zone I	20	40
Zone II..	12	24

Tariff amount as follows: Vessels will pay for each 100 tons of g.r.t. or fraction and for each 24 hours or fraction of time in Port.

Vessels up to 2,000 g.r.t.—90% of above table.

Vessels between 2,000 and 7,000 g.r.t.—same amounts as in table above.

Vessels over 7,000 g.r.t.—110% on amounts shown above.

Vessels remaining in port less than six hours, half above tariff.

Exemption from tariff: Vessels paying special tariff, i.e. yachts and cruising vessels, and complying with the rules of application specified by same.

Payment of berthing tariff does not exempt vessel from paying the above tariff.

For any further information, apply Port Authority.

Berthing Tariff: Vessel will pay for each metre or fraction, of length, and per 24 hours, or fraction of time while alongside, the following amounts:

Commercial berths—	Dique del Generalissimo ..	Ptas. 5.–
	Muelle de la Luz	„ 5.–
	Muelle Primo de Rivera ..	„ 4.–
	Muelle Santa Catalina	„ 3.–
	Espigon del Castillo	„ 3.–
Bunkering berth	—Dique del Generalissimo ..	„ 4.–

For vessels remaining in berth for less than six hours, ½ the above tariff payable.

Vessels moored stern or bows on to Moles will pay ½ the above tariff corresponding to vessels total length.

Towage—Harbour salvage tugs *Tamaran* 2,375 h.p., *El Guanche* 1,375 h.p., *Doramas* 1,313 h.p., *Nublo* 1,060 h.p., *Arucas* 2,200 h.p., *Gran Canaria* 2,830 h.p., *Castillejos* 650 h.p., *Espana II* 450 h.p., well equipped with salvage gear and fire fighting apparatus. On permanent service within the port.

Towage Tariff (Pesetas):

Assisted Vessel (g.r.t.)	*Tugs* 250 h.p. to 500 h.p.	500 h.p. to 1,000 h.p.	1,000 h.p. and over
Up to 1,000	1,376	1,834	1,834
1,001– 2,000	1,920	2,561	2,561
2,001– 3,000	1,920	2,561	2,561
3,001– 5,000	2,697	3,601	3,601
5,001– 7,000	3,842	5,123	5,123
7,001–10,000	5,146	6,859	7,363
10,001–13,000	5,834	7,780	9,604
13,001–16,000	6,178	8,235	10,164
16,001–19,000	6,178	8,235	10,725
19,001–22,000	6,523	8,692	11,284
22,001–25,000	6,859	10,256	11,345
25,001–30,000	6,859	10,256	12,805
30,001 and over for each 5,000 or fraction	400	1,720	2,402

Note: Tariffs are applicable only to towage services rendered within the limits of Puerto de la Luz, comprising the zone between the Generalisimo breakwater and the eastern coast of the port, and including an area lying within a radius of half a mile from the extremity of this breakwater.

Special Services—A surcharge of 50% of the tariff is applied to the following services: (a) those rendered between 1900 hours and 0700 hours; (b) services rendered on Sundays and holidays; (c) services rendered to vessels unable to steer and/or use own engines; (d) assistance to vessels entering or leaving dock or slipway; (e) complete service shifting from one berth to another.

Services rendered between 1200 and 1400 hours incur a surcharge of 25% of tariff.

Towing gear available for hire if required at Ptas. 400 per service to vessels under 10,000 g.r.t. and Ptas. 801 per service to vessels of over 10,000 g.r.t.

Surcharge of 100% applicable when vessel is unable to steer or use own engines within a radius of more than half a mile and less than one mile from the end of the Generalisimo breakwater, and 150% within a radius of one to two miles from the end of the breakwater.

Delays to interruption or commencement of service not imputable to tug charged at rate of Ptas. 8.003 per hr.

Half tariff will apply when tug is ordered and not utilised.

Pilotage—C. Daytime charges:

g.r.t.	In or Out	Movements	Mooring/ Unmooring
Up to 500 ..	Ptas. 110	Ptas. 130	Ptas. 55
501/ 1.000 ..	162	189	80
1.001/ 2.000 ..	218	254	108
2.001/ 3.000 ..	273	319	135
3.001/ 4.000 ..	328	384	163
4.001/ 5.000 ..	383	448	190
5.001/ 6.000 ..	438	513	218
6.001/ 7.000 ..	493	578	243
7.001/ 8.000 ..	548	643	273
8.001/ 9.000 ..	603	708	300
9.001/10.000 ..	658	773	328
10.001/11.000 ..	795	838	397
11.001/12.000 ..	854	903	428
13.001/14.000 ..	972	1.033	490
15.001/16.000 ..	1.090	1.162	552
17.001/18.000 ..	1.208	1.292	614
19.001/20.000 ..	1.326	1.422	676
21.001/22.000 ..	1.444	1.552	738
23.001/24.000 ..	1.562	1.682	800
25.001/26.000 ..	1.680	1.811	862
30.001/31.000 ..	1.975	2.136	1.017
35.001/36.000 ..	2.270	2.460	1.172
40.001/41.000 ..	2.565	2.785	1.327
45.001/46.000 ..	2.860	3.109	1.482
49.001/50.000 ..	3.096	3.369	1.606
Add for each additional 1.000 *g.r.t. (daytime)* ..	59	65	31
Add for each additional 1.000 *g.r.t. (holidays)*	88	97	46
Add for each additional 1.000 *g.r.t. (night-time)*	118	130	62

Sundays or holidays, day services add 50%. All night services add 100% to daytime charges. Exceptions to this rule are for vessels over 50,000 g.r.t., in which case, additions are those stated in the above table. (% addition first added to the 50,000 g.r.t.)

The above tariffs are subject to an authorised surcharge of 10% use of Pilot's VHF Station.

Traffic—Arrivals, 1973, 9,882 merchant vessels of 53,677,995 g.r.t., 6,398 trawlers of 3,944,407 g.r.t. Total oil traffic, 4,253,549 tons, 2,309,647 tons discharged and 1,943,902 tons bunkered.

Airport—Gando Bay, 26 km.

Local Holidays—April 29 (St. Peter Martyr) and September 8 (Virgin of the Pine).

Working Hours—Shifts worked: 08.00 to 14.00; 14.00 to 20.00. Overtime, 20.00 to 02.00 and 02.00 to 08.00.

Officials—Military authorities, Vice-Admiral Pedro Espanol Iglesias; Port Commandants, M. S. Barcaiztegui y Aznar, A. C. Cervera; Captain of the Port, Luis Sivera; Port Traffic and Services, Junta de Obras y Servicios: Engineer Director, D. J. A. Ulloa.

***Ports of the World* Correspondent:** Lloyd's Agents, Blandy Brothers Shipping & Agency S.A., Apartado 12, Las Palmas. London Correspondents: Blandy Brothers & Co. Ltd., 6 Broad Street Place, London, EC2M 7QS. Tel. 01-588 0953. Cables: Blandy, London, E.C.2.

PUERTO DE LA LUZ

(*See* Las Palmas)

PUERTO DEL ROSARIO, Fuerteventura

This port is growing in stature and is becoming more popular with cruise liners. Nearest major port Las Palmas.

Accommodation—Total quayage 320 m. Length of old section 220 m.; 150 m. of which has drafts of 5 to 7 m. at low tide, and a 100 m. extension has drafts alongside of 8 to 12 m. at low tide.

Towage—No tugs stationed at port but can be ordered from Las Palmas by prior arrangement.

Pilotage—Pilot meets vessels 1,000 m. off port.

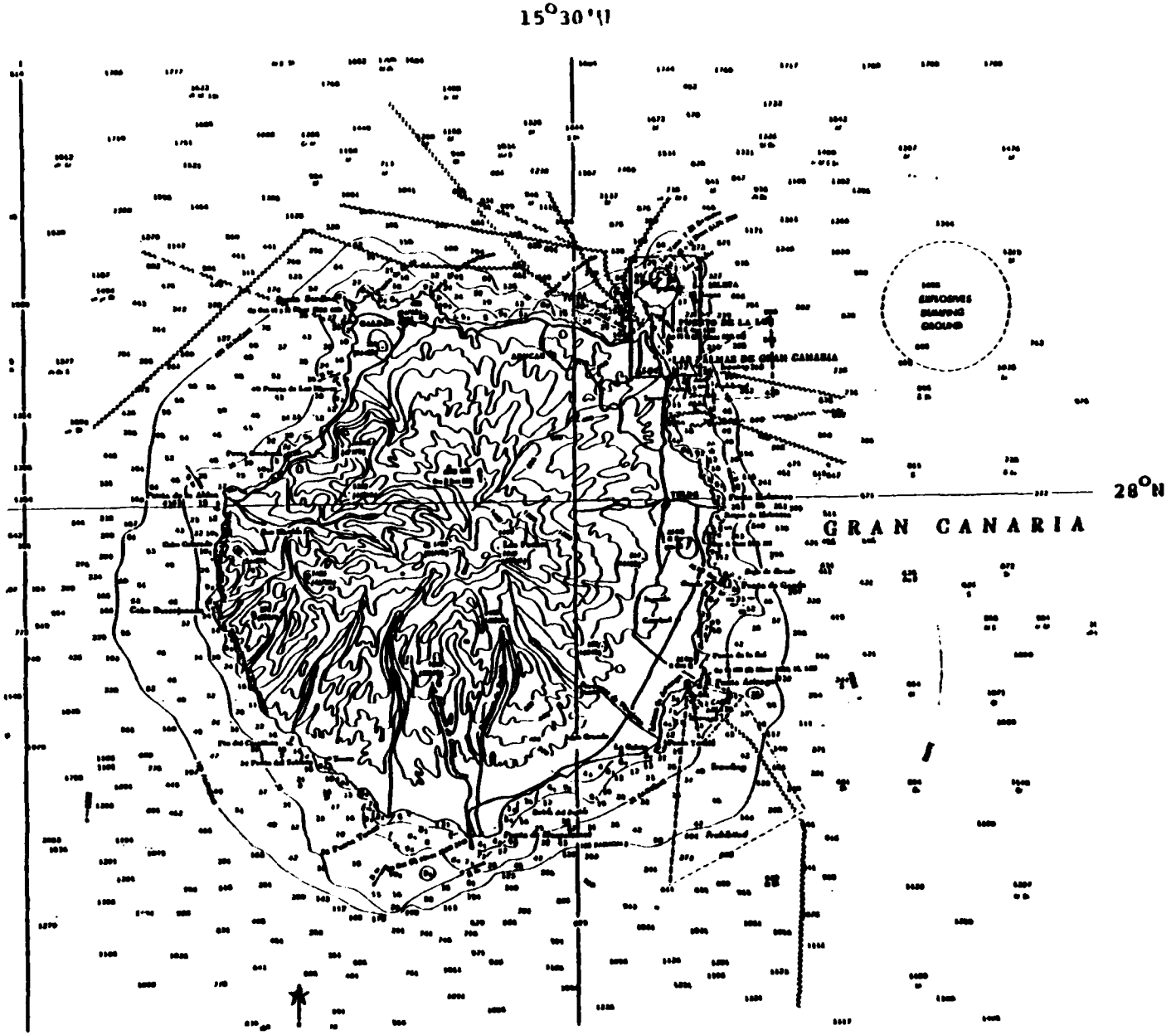
SANTA CRUZ, Tenerife

Lat. 28° 28′ 30″ N.; long. 16° 15′ 09″ W.

Authority—Comandante Militar de Marina (Marine Commandant) and Junta de Obras del Puerto (Harbour Board).

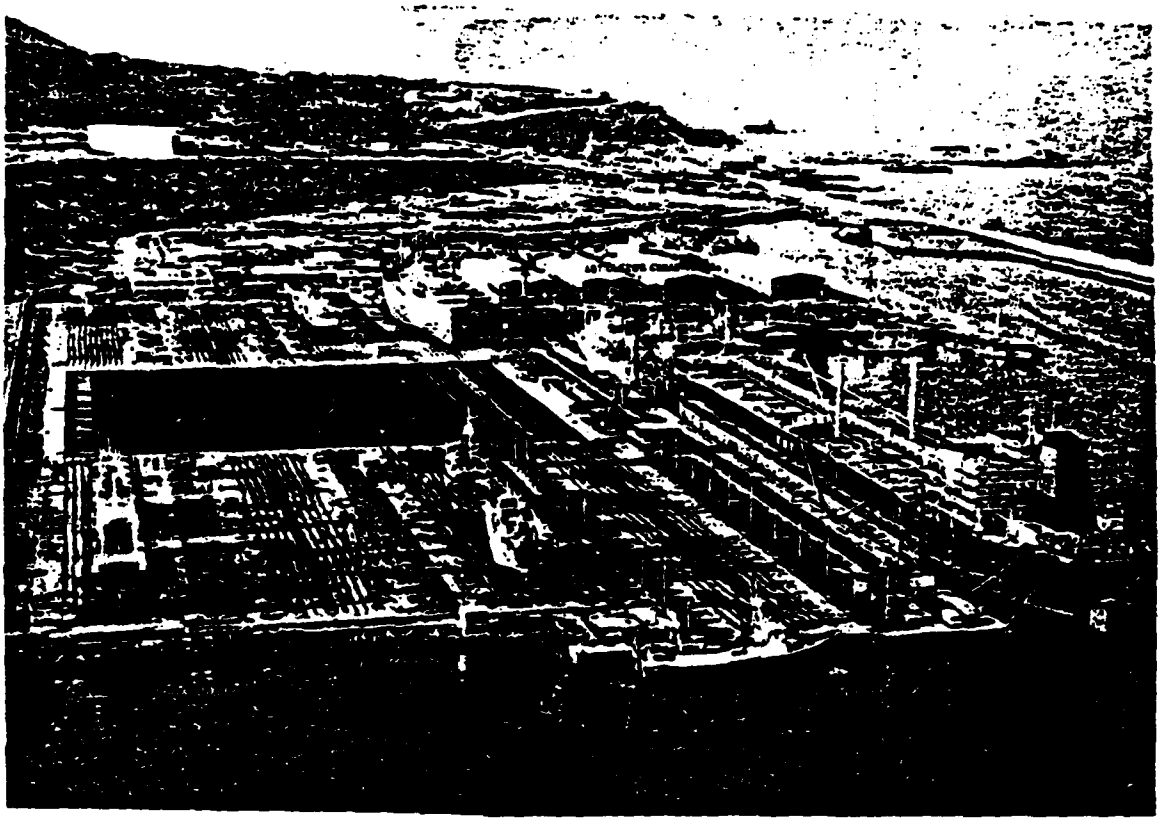
Accommodation—Outside the breakwater there is safe anchorage in from 4 to 12 fms. water. South Mole: Depth alongside at L.W. available for steamers: 116 m., 10 ft.; 239 m., 22 ft.; 240 m., 28 ft.; 214 m., 33 ft.; 800 m., 39 ft. 6 in. Length of vessel which can be berthed just under 800 m. o.a., depending on availability of berth. No breadth limitation. Largest vessel accommodated *S.S. France*. North Mole: Depth alongside at 26 ft. L.O.A. permitted 81 m. Quay space 3,400 sq. m., of which covered space amounts to 2,100 sq. m. Two 6-ton electric portal cranes. East Mole: depth alongside at L.W., 60 m. at 26 ft., 80 m. at 33 ft., 200 m. at 39 ft. 6 in., 700 m. at 18 m. Quay space, 3,960 sq. m. Night berthing possible. Vessels may berth at Master's discretion with bows overshooting end of mole. Owners of large tankers intending using this berth are recommended to seek advice of agents regarding tug requirements; berthing and unberthing are restricted to daylight hours for vessels of more than 70,000 d.w.t. Cold storage and ice factories: two situated near East Mole. Ribera Quay, depth alongside at L.W.: 286 m. at 23 ft.; 300 m. at 28 ft.; 537 m. at 33 ft. Quay space 28,230 sq. m. of which 13,800 sq. m. are covered. Four 6-ton electric portal cranes and eight 3-ton portal cranes. Fishing craft harbour situated one mile North of East Mole provides 600 m. of berthing space with 18 ft. draft alongside L.W.O.S.T. Width of harbour, 150 m. 335,000 sq. m. of land will be allocated for approach roads, offices, cold storage, workshops, net repair areas, car parks, water storage, etc. *Floating Pipeline:* Situated at a right angle to the East Mole, property of C.E.P.S.A. (Spanish Petroleum Company). Maximum capacity 120,000 t.d.w. Tankers may bunker at this terminal subject to availability of berth. One of the main crude oil discharging berths. Berthing and unberthing only between 06.00 and 18.00 hours. Duque of Alba Loading Stage: Property of C.E.P.S.A. (Spanish Petroleum Company) situated at Puerto Honduras, 3 miles south of Santa Cruz. Limitations 45,000 t.d.w. Main refined spirits and L.P.G. loading stage, although subject to berth being available, vessels may bunker. Three cold storage warehouses available: (1) Frio Industrial SA; (2) Frigorificos del Atlantico SA; (3) Frigorificos Salvador Vazquez:

(1) Storage capacity 3,073 m³. Ice production 240 tons per day—deep freeze tunnel, 12 tons per day at minus 35°C.;


15°30'W
28°N
GRAN CANARIA
LAS PALMAS DE GRAN CANARIA

ASTICAN

ASTILLEROS CANARIOS, S.A.



THE LARGEST SHIPYARD IN THE CANARY ISLANDS AND WEST COAST OF AFRICA

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APPENDIX D

CONFIGURATION I DEPLOYMENT PLAN

(PRELIMINARY)

25 September 1980

PRELIMINARY

MARINE SEISMIC SYSTEM PROGRAM

CONFIGURATION I DEPLOYMENT PLAN SYNOPSIS

(June-July 1982)

PREPARED BY

GLOBAL MARINE DEVELOPMENT INC.
2302 MARTIN STREET
IRVINE, CALIFORNIA 92715

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APPENDIX D

CONFIGURATION I DEPLOYMENT PLAN

(PRELIMINARY)

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VIII.	SPECIAL CONSIDERATIONS	6
IX.	TEST PERSONNEL	6

MSS DEPLOYMENT

CONFIGURATION I DEPLOYMENT PLAN SYNOPSIS

I. OBJECTIVES

The primary objective is to provide a prototype demonstration for the deepwater borehole BIP concepts, specific goals are:

1) Demonstrate deepwater Configuration I instrumented package operation in a drilled out borehole within basalt.
2) Demonstrate deployment of Configuration I BIP and associated equipment.
3) Demonstrate three months of prototype MSS system operation.
4) Demonstrate feasibility of Configuration II fly-in platform reentry.

Deepwater BIP reentry into a borehole will be demonstrated utilizing the baseline concept which lowers the BIP at the end of a drill string. Short and long period seismic data from within the existing borehole is to be provided to confirm sub-seabed installation effectiveness. Tentatively BIP is to be cemented into the borehole.

II. ORGANIZATION RESPONSIBILITIES

The following responsibilities are:

Program Management	NORDA
Test Direction	
Test System Integration and Technical Coordination	GMDI
CHALLENGER Operations	DSDP/NSF/GMDC
Reentry Test Equipment	GMDI

BIP Test Package	GEOTECH
Reentry Data Monitoring Equipment	GMDI
EM Cable and Winch	GEOTECH
Seismic Data Monitoring Equipment	GEOTECH
CHALLENGER Modifications	GMDC/GMDI
Deployment Procedures	GMDI
Test Logistic Support in San Juan	GMDI
Current Meter Equipment	NORDA
Demobilization	GMDI
Subsurface Buoy	
Mooring Equipment	

III LOCATION

The proposed tests will tentatively be accomplished in the North Pacific area. Five sites are being considered. These sites are located near the 45 degree North parallel and the 160 degree West Meridian.

IV SCHEDULE

The proposed test will take place in the June-July period 1982 during the tentative CHALLENGER transit leg from Japan to Alaska. Total estimated time of CHALLENGER at-sea involvement is 40 days for the drilling out two boreholes, deploying one Configuration I MSS System and testing a fly-in platform.

It is estimated that in-port loading, installation and checkout of test equipment will be accomplished in parallel to other regular DSDP logistic efforts. Unloading should take 1/2 day if full retrofit is not required. A receiving and test facility in Japan is to be available 2 months before installation.

V TEST AGENDA

The following preliminary MSS agenda has been tentatively established:

		EST. TIME
1)	Transit and establish first site position	4 days
2)	Test coring	6 days
3)	Drill and encase first borehole	7 days
4)	Deploy Config. I BIP and associated equipment	4 days
5)	Transit and establish second borehole	2 days
6)	Test coring	6 days
7)	Drill and encase second borehole	7 days
8)	Fly-in platform reentry demonstration	4 days
	TOTAL	40 days

VI EQUIPMENT REQUIREMENTS

The following At-Sea-Test equipment has been defined for the baseline and alternate concepts. The alternate fly-in platform equipment requirements may be revised dependent upon the conceptual design definition.

1)	Config. I Baseline Reentry	Responsibility	Remarks
	BIP reentry test package	GEOTECH	
	EM Cable	GEOTECH	NORDA Supplied
	Reentry tool (sonar) and readout console	GMDI	
	Reentry sub (20,000 ft. depth) includes release mechanism, reentry tool support and shock absorber	GMDI	
	BIP recording console van	GEOTECH	
	Reentry tool winch and cable	--	Onboard Schlumberger Winch/Cable
	BIP EM Cable diesel winch	GEOTECH	Navy Spec.
	A-Frames including foundations	GMDI	
	Reentry cone, casings and hangers (2)	GMDI	
	Miscellaneous handling equipment	GMDI	
	Deployable current meter string (20,000 ft)	NORDA	
	OBS Seismic Package	NORDA	
	ASK Beacons	DSDP	
	Mooring System		
	Subsurface Buoy		
	Data Recovery Equipment		
	Anchor Handling Winch	NORDA	
	Anchor Handling Pendant	GMDI	
	Drill bits	GMDI	
	Cement	GMDI	
	Borehole Angle Instr.	GMDI	
	Special Drill Collars	GMDI	
2)	Fly-in Reentry Test		
	Fly-in-platform	GMDI	
	Lowering Winch and Line	NORDA	
	Position monitor	GMDI	
	Dummy BIP	GEOTECH	Maybe At-Sea-Test BIP

VII TEST DATA OBJECTIVES

1) Seismic In Hole Demonstration (30-90 days Real Time)

 Short period seismic data (recorder)

 Long period seismic data (recorder)

 OBS camparative data

 State of health data

 Verification of control functions

2) Reentry Demonstration

 Reentry sub velocity (lateral)

 Reentry sub position relative to ship and reentry cone

 Ship stationkeeping characteristics

 Current profile with depth

 Cable tension

 BIP Azimuth

 Reentry stabbing velocity

3) Lowering Demonstration

 BIP lowering velocity

 Surface cable payout

 Lowering cable tension

4) Mooring Deployment

 Characteristics of deep water moor

 Cable dynamic tension

5) Fly-In Platform Reentry

 Positioning characteristic of surface vessel

 Thruster augmentation

 Reentry velocities

 Cable dynamics

VIII SPECIAL CONSIDERATIONS

1) The use of the high strength drill string is an expensive and long lead procurement item. Present responsbility for the drill string lies with DSDP.

2) Test coring of both borehole sites may be required.

3) Installation of cementing is included in one site.

4) A spare BIP and reentry sub will be provided.

IX TEST PERSONNEL

Accomodations for At-Sea-Test personnel will be as follows:

NORDA	3
GMDI	3
GEOTECH	3
DARPA	1
	10

APPENDIX E

IMPACT FORCES REPORT

NOTE: This Appendix E contains three (3) Supplimental Appendices A, B, and C.

RPT-001-001
Revision 2
29 October 1980

MARINE SEISMIC SYSTEM

REENTRY IMPACT

(JOB 00001, TASK 210200)

12 AUGUST 1980

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REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
0	08-12-80	S. Wetmore	Initial Release	All
1	09-25-80		Shock Absorber between DP and RS (Alternate 1) removed. Related analysis omitted from the report. pages, 3,4,5,6,21,22,23,24,25,26, 28,31,32	All
2	10-29-80	Y. Ozudogru S. Wetmore	Three Apendices are added: App. A. - Reentry Impact Analysis for elastic connection between the drill pipe and reentry sub, App. B - BIP isolation during the reentry sub impact, App. C - Reentry sub motion after the impact. Table 4.1 is omitted, Section 2.0 is added with two objectives, Sec. 4.0 is changed and results of Appendices A,B and C are included, Sec. 5.16, 5.17 and 5.18 are added, Section 5.15 has been changed.	

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1.0 ABSTRACT

This report deals with the problem of the reentry impact which takes place at the last stage of the Borehole Instrumentation Package (BIP) deployment. The analysis includes evaluation of the impact impulse, impact duration, impact force, velocity distribution after the impact, acceleration distribution along the Reentry Sub (RS) during the impact, and bending stress at the joint between the RS and Drill Pipe (DP). Results are obtained for two design alternatives with and without the proposed shock absorber. Numerical results based on the preliminary input data are provided in graphical form. These results can be used for a wide range of the RS mass and geometrical characteristics.

2.0 OBJECTIVES

The following objectives are considered in this report (FIG. 2.1):

- Provide information for stress analysis of the RS,
- Evaluate maximum accelerations and their distribution along the RS during the reentry impact,
- Generate some recommendations regarding the optimum design of the RS,
- Investigate RS motion after the impact,
- Study an isolation system to decrease dynamic load applied to the BIP during the impact.

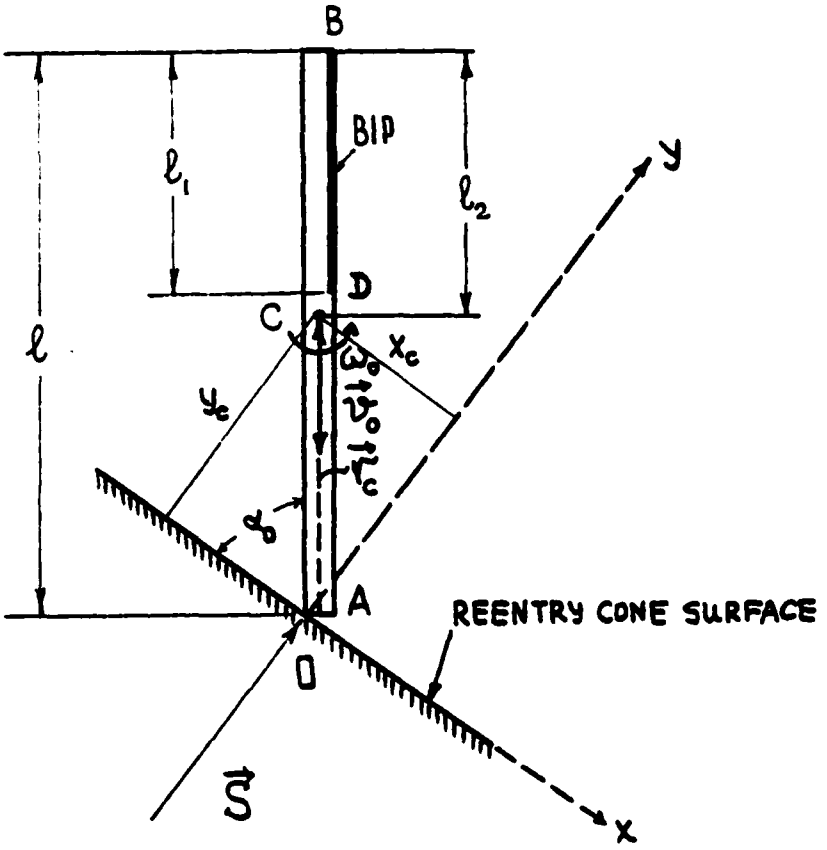


FIGURE 2.1 CALCULATION SCHEME AND COORDINATE SYSTEM

3.0 DESIGN REQUIREMENTS

The following design requirements are considered:

- RS velocity before impact - 10 FT/SEC,
- RS material - steel,
- Reentry Cone material - steel,
- ANGLE between the generator of the reentry cone and the vertical - 30^{o},
- RS length - 60 FT,
- RS dry weight - 15,000 LBS,
- BIP location as shown in FIG. 2.1,
- BIP length - 30 FT,
- Length of the drill pipe (DP) - 20,000 FT,
- During impact the BIP can sustain an acceleration of 10g (where g denotes the gravitational acceleration),
- DP material - steel,
- DP diameters: outside - 5", inside - 4.125" ,

4.0 SUMMARY OF RESULTS

General results of this investigation are summarized as follows:

- Two alternatives of the connection between the reentry sub and drill pipe are considered: first-rigid joint, second-elastic joint by means of a shock absorber at the upper end of the reentry sub. Analysis concerning the first alternative is described in the main part of this report, analysis related to the second alternative is located in Appendix A.
- The determining factor for the RS reentry is

the impact impulse applied to the striking end of the RS and the reentry cone surface. This impulse does not exceed 1114 LBS. SEC. for the elastic joint and 1148 LBS. SEC. for the rigid joint.

- Impact force applied to the lower end of the RS is essentially dynamic and depends on several characteristics of the RS: mass and its distribution, mass moment of inertia, elastic properties of the RS and reentry cone material, RS geometry, reentry cone angle, contact stresses, type of connection between the RS and DP, duration of the impact. Maximum impact force is evaluated in the range of 164 - 243 KIPS. The lower value corresponds to the rigid connection, the upper - to the elastic one.
- Duration of the impact is recommended to be determined experimentally. At this stage of preliminary investigation of the problem the time duration is estimated in the range of 7-11 milliseconds.
- Velocity distribution along the RS after the impact was determined for two bounding assumptions: First - there is no horizontal component of the resistant force applied to the upper end of the RS during and after the impact, Second - after the impact the upper end of the RS will move along vertical and the lower end - along the reentry cone generator. Velocity distribution for both

cases is shown in FIG. 5.6 and Table C.4 (Appendix C). There is no practical difference in velocity distirbution after the impact for rigid and elastic connection between the RS and DP.

- Angular velocity of the RS with respect to its center of mass after the impact is determined in the range of 0.20-0.21 sec^{-1} for the first assumption, and in the range of 0.09 sec^{-1} for the second assumption.
- The magnitude of the RS rotation with respect to its center of mass in motion after the impact is in the range of 6.7^{o}-9.4^{o}. Factual result is expected to be close to the lower limit of this range.
- Distribution of accelerations along the RS depends upon the type of the joint between the RS and the DP and assumptions accepted. The upper limit of accelerations corresponds to the assumption of no horizontal resistance at the upper end of the RS. Magnitude of accelerations is less for rigid joint: 12.4g vs. 18.9g for the upper end, 6.8g vs. 10.4g for the center of mass, 23.7g vs. 36.9g for the striking end.
 If the second assumption about the motion of the RS during and after the impact is made, analysis shows substantial decrease in accelerations: they (Table C.8, Appendix C) are in the vicinity of 1g for all points of the RS. Actual values

of accelerations probably will be between this two limits.

- Shock absorber at the upper end of the RS decreases the force applied due to impact 5.4 times. Axial force applied to the lower end of the drill pipe for elastic joint is 470 LBS vs. 2,520 LBS for joint without a shock absorber. For stiffness of 100,000 LBS/FT maximum displacement of the absorber can be expected in the range of 0.06 inches.
- Concentrated bending moment applied to the lower end of the drill pipe may occur due to reentry impact. According to conservative evaluation the maximum value of this moment may be expected in the range of 15,385 LBS.FT. That corresponds to a conservatively estimated bending stress of about 28,000 psi.
- Installation of an elastic component at the striking end of the RS or at the reentry cone surface can increase the energy absorbtion capability of the RS during the impact. Therefore, it is recommended to envelope this area with a resilient material.
- Analysis of BIP isolation is described in Appendix B. It is based on the upper limit of predicted accelerations and dynamic loading. Two bushings made from 50 durameter rubber with

the shape factor of 1.1 can substantially reduce the load transfered to the BIP due to impact. Analysis showed that these bushings might reduce the dynamic loads practically to zero even in the worst case under consideration.

5.0 TECHNICAL DISCUSSION

5.1 FORMULATION OF THE PROBLEM

Knowing the reentry velocity of the RS and the angular velocity of it with respect to the mass center before the impact, it is necessary to determine:

- value of the impact impulse,
- value of the impact force applied to the lower end of the RS,
- impact duration,
- velocity distribution along the RS after impact,
- acceleration distribution along the RS during the impact.

5.2 ASSUMPTIONS

Three assumptions are considered:

- RS (with BIP) and reentry cone are simulated as rigid bodies,
- RS motion before impact is a plane motion in vertical plane,
- Friction between the RS and the surface of the reentry cone is neglected.

5.3 GENERAL EQUATIONS OF THE RS MOTION AFTER IMPACT IN VECTOR FORM

According to the impulse-momentum and moment of momentum theorems (Reference 1) for the time of impact duration, equations of the RS motion after the impact have the form:

$$M(\vec{v}-\vec{v}_0)=\vec{S}, \qquad (5.1)$$
$$J_c(\vec{\omega}-\vec{\omega}_0)=\vec{m}_c(\vec{S}),$$

where M = total mass of the system (RS) involved in the impact,

J_c = moment of inertia of this system with respect to its mass center,

$\vec{S}$ = impact impulse,

$\vec{v}_0, \vec{v}$ = velocity of the mass center before and after the impact,

$\vec{\omega}_0, \vec{\omega}$ = angular velocity vectors of the RS with respect to the mass center before and after the impact,

$\vec{m}_c(\vec{S})$ = vector- moment of the impact impulse with respect to the mass center.

The following relations should be added to the set (5.1):

- Kinematic relationship between the velocity of the striking end of the RS (point A, FIG. 2.1) and the velocity of the mass center (point C) before and after the impact

$$\vec{V}_0 = \vec{v}_0 - \vec{\omega}_0 \times \vec{r}_c ,$$

$$\vec{V} = \vec{v} - \vec{\omega} \times \vec{r}_c , \qquad (5.2)$$

where $\vec{r}_c$ denotes the radius-vector of the mass center (FIG. 2.1),

- Shock condition (Reference 2)

$$V_y + \kappa V_{oy} = 0, \tag{5.3}$$

where κ is the coefficient of restitution and V_{oy}, V_y denote projections of the velocity-vector of the striking end of the RS on the axis Oy before and after the impact, respectively. Equations (5.1) through (5.3) can be reduced to a set of 7 scalar equations containing 7 unknowns: $v_x, v_y, \omega, V_x, V_y$, S_x and S_y. Consequently, the problem is completely described by this set of equations.

5.4 SCALAR EQUATIONS OF THE RS MOTION

Projecting equations (5.2) on the axes Ox and Oy, one can write

$$\begin{aligned} V_{ox} &= v_{ox} + \omega_0 y_c, \quad & V_{oy} &= v_{oy} - \omega_0 x_c, \\ V_x &= v_x + \omega y_c, \quad & V_y &= v_y - \omega x_c, \end{aligned} \tag{5.4}$$

where x_c, y_c denote the coordinates of the mass center of the RS (FIG. 2.1) and the subscripts x and y correspond to the projections on the appropriate axes. Equations (5.1) in scalar form are:

$$\begin{aligned} v_x &= v_{ox} + S_x/M, \\ v_y &= v_{oy} + S_y/M, \\ \omega &= \omega_0 - \frac{1}{J_c}\left(x_c S_y - y_c S_x\right). \end{aligned} \tag{5.5}$$

Eliminating v_{ox} and v_{oy} from equations (5.4) and (5.3) by means of relations (5.5), we obtain

$$V_x = V_{ox} + \frac{1}{J_c}\left[(\rho_c^2 + y_c^2) S_x - x_c y_c S_y\right],$$
$$V_y = V_{oy} + \frac{1}{J_c}\left[(\rho_c^2 + x_c^2) S_y - x_c y_c S_x\right]. \qquad (5.6)$$

Here ρ_c denotes the radius of inertia $\rho_c = \sqrt{J_c/M}$. These two equations and equation (5.3) contain 4 unknowns: V_x, V_y, S_x, S_y. One additional equation may be written if the character of the surfaces involved in the impact is considered.

5.5 GENERAL SOLUTION OF THE IMPACT PROBLEM IN CASE OF SMOOTH REENTRY CONE SURFACE

According to the third assumption made in Section 5.2, it can be written

$$S_x = 0. \qquad (5.7)$$

This means that the impulse vector is directed along the normal to the reentry cone surface (FIG. 2.1). Omitting details, we consider the final form of the equations governing the problem:

$$v_x = v_{ox}\,;\quad V_{ox} = v_{ox} + \omega_0 y_c\,;\quad V_{oy} = v_{oy} - \omega_0 x_c\,; \tag{5.8}$$

$$v_y = v_{oy} - \frac{\rho_c^2(1+K)}{\rho_c^2 + x_c^2} V_{oy}\,;\quad \omega = \omega_0 + \frac{(1+K)\,x_c}{\rho_c^2 + x_c^2} V_{oy}\,;$$

$$S = S_y = -\frac{J_c(1+K)}{\rho_c^2 + x_c^2} V_{oy}\,.$$

Components of the velocity vector of the lower end of the RS after impact can be determined by means of relations (5.6)

$$V_x = V_{ox} - \frac{x_c y_c}{J_c} S\,,$$
$$V_y = V_{oy} + \frac{\rho_c^2 + x_c^2}{J_c} S\,. \tag{5.9}$$

5.6 COEFFICIENT OF RESTITUTION

This coefficient in actual problems may have values in the range between 0 and 1. The value 0 corresponds to absolutely unelastic impact, and the upper limit corresponds to an absolutely elastic impact. The values of K are determined experimentally or by analysis of wave stress propagation. The latter is possible in simple homogeneous problems with classical boundary conditions. At least three factors affect the value of the coefficient of restitution in the problem under consideration:

- Materials of the RS and reentry cone,
- Shape of the striking end of the RS,
- Intensity of the impact stresses.

It is recommended that the value of this coefficient

be determined experimentally. At the stage of preliminary evaluation of the main governing parameters the coefficient of restitution is taken equal 5/9 (Reference 3). More information about the coefficient of restitution can be found in Reference 1 (page 23-g), Reference 2 (page 9-4), Reference 4.

5.7 TIME DURATION OF THE IMPACT

The duration of the impact τ is related to the value of the coefficient of restitution K and mass-geometrical and elastic characteristics of the striking RS and the reentry cone. This value should be determined experimentally as well as the value of K.

To evaluate the expected value of τ, a classical approach based on the wave propagation in the RS simulated as an elastic homogeneous bar is used. According to this theory (References 2,4,5 and 6), the value of τ is equal to the time which is necessary for a stress wave to cover the distance 2ℓ, i.e double length of the RS

$$\tau = \frac{2\ell}{c} , \qquad c = \sqrt{\frac{E}{\rho}} , \tag{5.10}$$

where E is modulus of elasticity of RS material, ρ denotes the mass density of it.

Expression for C determines the sound velocity in material which is used for the RS. Accordingly, for steel $E=30\cdot10^6$ psi, $\rho=15.5$ LBS·SEC^2/FT^4 (Reference 7), $C=16700$ FT/SEC.

5.8 IMPACT FORCE APPLIED TO THE LOWER END OF THE RS

Assume that the impact force $F(t)$ changes its value during the impact according to the half-sine law (FIG. 5.1) (References 1,2)

$$F(t)=F_{MAX}\sin\frac{\pi t}{\tau}, \quad 0\le t\le\tau. \tag{5.11}$$

Then the maximum value of this force is given by relation

$$F_{MAX}=\frac{\pi S}{2\tau}, \tag{5.12}$$

where S is the impact impulse of this force. This force can be decomposed on two components vertical F_v and horizontal F_h

$$\begin{aligned} F_v &= F_{MAX}\cdot\sin\alpha_0, \\ F_h &= F_{MAX}\cdot\cos\alpha_0. \end{aligned} \tag{5.13}$$

Vertical component F_v will cause dynamic compressive stress in the reentry sub, the horizontal component-bending and (or) rotation of the RS with respect to the upper end of it.

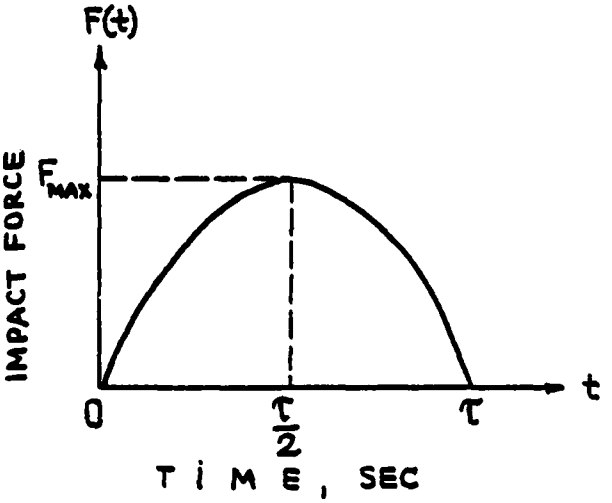


FIGURE 5.1 CONFIGURATION OF THE IMPACT IMPULSE

5.9 VELOCITY DISTRIBUTION ALONG THE RS AFTER THE IMPACT

After the reentry impact the RS moves in the vertical plane. Knowing the velocity of the mass center C and the angular velocity with respect to it ω, the vector velocity of any point K at the RS can be calculated according to relation

$$\vec{V}_K = \vec{v}_c + \vec{V}_{KC} \quad , \quad \vec{V}_{KC} = \vec{\omega} \times \vec{r}_{CK} \quad , \tag{5.14}$$

where $\vec{V}_{KC}$ denotes the velocity of the point under consideration in the rotation of the RS with respect to the mass center, and $\vec{r}_{CK}$ is the vector of the point K with respect to the same center.

Results are displayed in graphical form by means of the instantaneous center of velocities C_v and plane of velocities (Reference 1). These displays are shown in Sections 5.15.2 for every alternative considered. The procedure of determining the point C_v is provided in (FIG. 5.2).

5.10 DISTRIBUTION OF ACCELERATIONS ALONG THE RS DURING THE IMPACT

This matter is extremely important because of strong

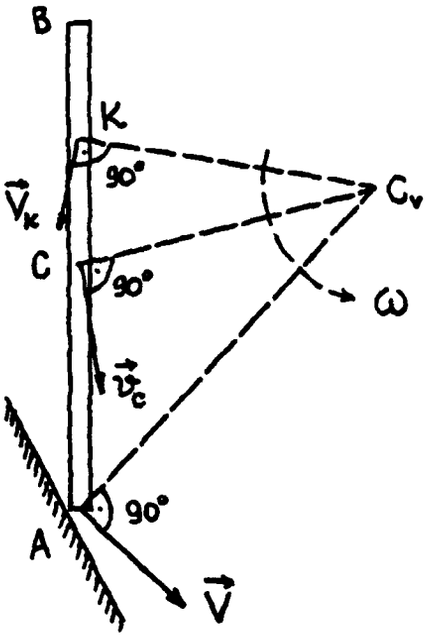


FIGURE 5.2 INSTANTANEOUS CENTER OF VELOCITIES C_v AND ITS DETERMINATION:

- FIND $\vec{v}$ AND PLOT IT,
- FIND $\vec{V}$ AND PLOT IT,
- FIND POINT C_v AS AN INTERSECTION OF TWO PERPENDICULARS $\vec{CC}_v \perp \vec{v}$ AND $\vec{AC}_v \perp \vec{V}$,
- FOR ANY POINT K CALCULATE $|KC_v|$,
- CALCULATE $V_k = |KC_v| \cdot \omega$,
- PLOT $\vec{V}_k \perp \vec{KC}_v$ IN DIRECTION OF ω.

limitation of maximum accelerations applied to the BIP.

Components of the acceleration vector of the mass center is determined by following relations

$$W_x = \frac{v_x - v_{ox}}{\tau} , \qquad W_y = \frac{v_y - v_{oy}}{\tau} . \tag{5.15}$$

Then for the absolute value of the acceleration of the mass center one gets

$$W_c = \sqrt{W_x^2 + W_y^2} , \quad \beta = \tan^{-1} \frac{v_y - v_{oy}}{v_x - v_{ox}} , \tag{5.16}$$

where β denotes the angle between the vector $\vec{W}_c$ and positive direction of the axis Ox (FIG. 2.1). Acceleration of any arbitrary point K is

$$\vec{W}_K = \vec{W}_C + \vec{W}_{KC} , \quad W_{KC} = KC \cdot \sqrt{\varepsilon^2 + \omega^4} , \tag{5.17}$$

where $\vec{W}_{KC}$ is the acceleration of this point in rotational motion about the mass center with angular velocity ω and angular acceleration ε .

To determine ε, one has assume any distribution of its value during impact. We accept ε = CONST. Then

$$\varepsilon = \frac{\omega - \omega_o}{\tau} , \tag{5.18}$$

where ω_o is the angular velocity of the RS before

impact. To have a pictorial distribution of the accelerations, the instantaneous center of accelerations C_w can be introduced. To find this point, one has to turn the vector $\vec{w}_c$ in the direction of ε at the angle μ

$$\mu = \tan^{-1} \frac{|\varepsilon|}{\omega^2} \tag{5.19}$$

and find this point so, as

$$CC_w = \frac{w_c}{\sqrt{\varepsilon^2+\omega^4}} . \tag{5.20}$$

Then, the acceleration of any point K can be found as follows:

$$w_K = w_{K\hat{C}_w} = KC_w \sqrt{\varepsilon^2+\omega^4} . \tag{5.21}$$

The vector $\vec{w}_K$ has the same angle μ (5.19) with the direction $\vec{KC}_w$ as the vector $\vec{w}_c$, in other words, to obtain $\vec{KC}_w$ the vector $\vec{w}_K$ has to be turned about the point K on the angle μ in the direction of the angular acceleration ε (FIG.5.3).

5.11 MAGNITUDE OF THE RS ROTATION AFTER THE IMPACT

It was shown in Section 5.5 that the RS would have motion in vertical plane with angular velocity ω after the impact (FIG. 5.4). The rotation can be with respect to the mass center of the RS. The magnitude

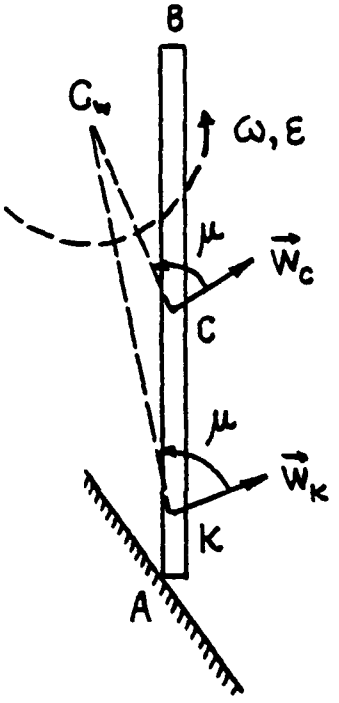


FIGURE 5.3 INSTANTANEOUS CENTER OF ACCELERATIONS C_w AND ITS DETERMINATION

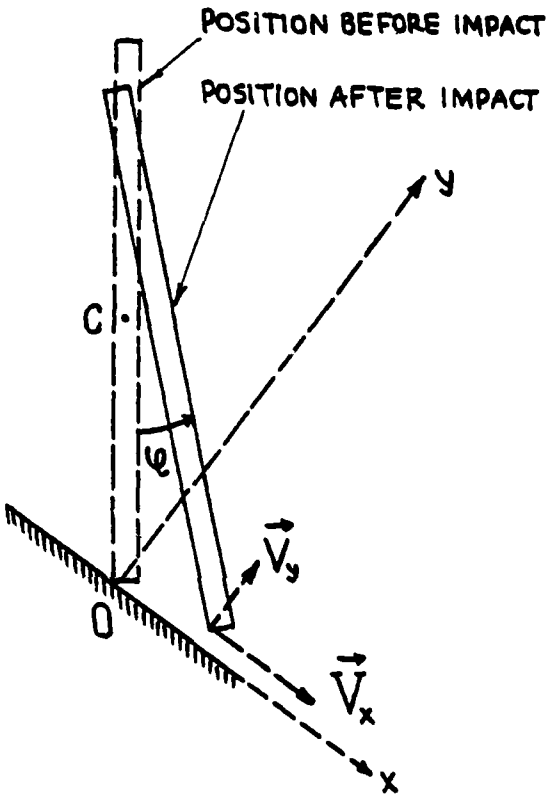


FIGURE 5.4 REENTRY SUB CONFIGURATION BEFORE AND AFTER THE IMPACT

of it is restricted by the following factors:

- Stiffness of the joint at the upper end of the RS,
- Dissipation of energy due to water.

To simplify the problem and evaluate the upper limit of the magnitude of this rotation, the aspect of energy dissipation in water is neglected. The mathematical model of the problem considered is shown in FIG. 5.5.

The bending rigidity of the DP. EI and the effective length L of it are taken into consideration. It is assumed, that the upper end of the active part of the DP, is fixed.

If bending stiffness of a cantilever beam due to lateral force and concentrated moment at the free end is taken into consideration (Reference 8), differential equation governing the problem can be written in the form:

$$J_c \ddot{\varphi} = -\frac{2EI\ell_2}{L^2}\varphi - \frac{EI}{L}\varphi. \qquad (5.22)$$

The first item at the right side expresses the resistance of the DP due to shear force, the second corresponds to the bending stiffness of the joint. This

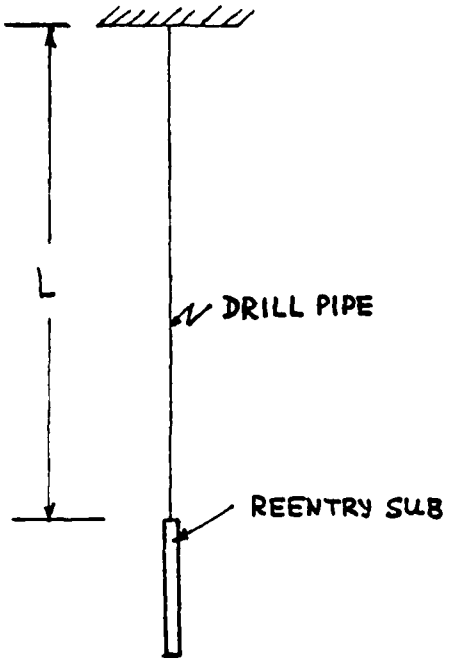


FIGURE 5.5 MATHEMATICAL MODEL OF DP AND RS

of the joint. This equation can be rewritten as follows:

$$\ddot{\varphi} + n^2 \varphi = 0$$

with

$$n^2 = \frac{1}{J_c}\left(\frac{2EI\ell_2}{L^2} + \frac{EI}{L}\right) \tag{5.23}$$

Solution of the equation above for initial conditions $\varphi = 0, \dot{\varphi} = \omega$ when $t = 0$ is

$$\varphi(t) = \frac{\omega}{n} \sin nt \tag{5.24}$$

with the magnitude

$$\varphi_{max} = \frac{\omega}{n}\,, \tag{5.25}$$

where n is the natural frequency of the RS rotation with respect to the mass center. As one can see, this magnitude depends on:

- reentry sub mass moment of inertia,
- distance between the mass center and the upper end of the RS,
- bending rigidity of the DP,
- effective length of the DP involved in the impact.

5.12 EFFECTIVE LENGTH OF THE DP

We denote by effective length of the DP the real

length which is involved in the impact. Exact answer hardly can be obtained since the picture of propagating and reflected waves generated by the impact is very complicated because of nonhomogeneity of the structure. The DP is composed from 30FT segments with very rigid connection between them. The length of 30FT is considered as the effective length of the DP, i.e. L =30FT.

5.13 NATURAL FREQUENCY OF THE RS ROTATION WITH RESPECT TO ITS MASS CENTER

According to relation (5.23) and accepting $E=30\cdot144\cdot10^{6}$ PSF, $I=7.95\cdot10^{-4}$ FT^4 (Reference 9), one can evaluate the natural frequency n

$$n=\left[(7632\,\ell_2+114480)\cdot\frac{1}{J_c}\right]^{0.5}.$$

Notice, that length is measured here in FT.

5.14 NUMERICAL RESULTS FOR RIGID CONNECTION BETWEEN THE RS AND DP

5.14.1 NUMERICAL INPUT

Velocity of the RS mass center before impact $V_0 = 10 \frac{FT}{SEC}$,

angular velocity of the RS before impact $\omega_0 = 0$,

Reentry cone angle $\alpha_0 = 30°$,

Coefficient of restitution $K = 5/9$,

Dry weight of the RS $Q = 15000$ LBS ,

RS length $\ell = 60$ FT ,

Mass of the effective length of the DP 15.3 $\frac{LBS.SEC^2}{FT}$

(corresponds to 16.4 LBS per 1 FT of the DP weight),

Distance between the mass center and the upper end

$\ell_2 = 29.05$ FT .

Other numerical input:

v_{ox} = 8.66 FT/SEC v_{oy} = -5.0 FT/SEC.

M = 481.5 $\frac{LBS.SEC^2}{FT}$

X_c = -26.80 FT. Y_c = 15.48 FT

J_c = 152924.6 LBS.FT.SEC^2

ρ_c = 17.82 FT.

5.14.2 NUMERICAL OUTPUT (SEE SECTION 5.5)

v_x = 8.66 FT/SEC. v_y = -2.61 FT/SEC.

V_{ox} = 8.66 FT/SEC, V_{oy} = -5.0 FT/SEC.

ω = 0.20 SEC^{-1}, S = 1148.3 LBS.SEC.

V_x = 11.77 FT/SEC, V_y = 2.78 FT/SEC,

n = 1.48 SEC^{-1}, φ_{max} = 7.7°,

τ = 0.011 SEC, F_{max} = 163977 LBS,

F_v = 81988 LBS, F_h = 142008 LBS,

Distribution of velocities after impact is displayed in FIG. 5.6. Distribution of accelerations is shown in (FIG. 5.7).

5.14.3 BENDING MOMENT AND BENDING STRESS AT THE LOWER END OF THE DP DUE TO RS ROTATION AFTER IMPACT

This concentrated bending moment is caused by the rotation of the RS. According to Reference 8 , the value of the bending moment is

$$m = \frac{EI}{L}\varphi,$$

where φ is the angle measured in radians. Maximum bending moment corresponds to the magnitude of the angle φ= 7.7° (or 0.1344 radians)

$$m = 15{,}385 \text{ LBS·FT.}$$

Maximum bending stress at the joint due to rotation of the RS after impact can be predicted at the level of

$$\sigma = 27{,}998 \text{ Psi.}$$

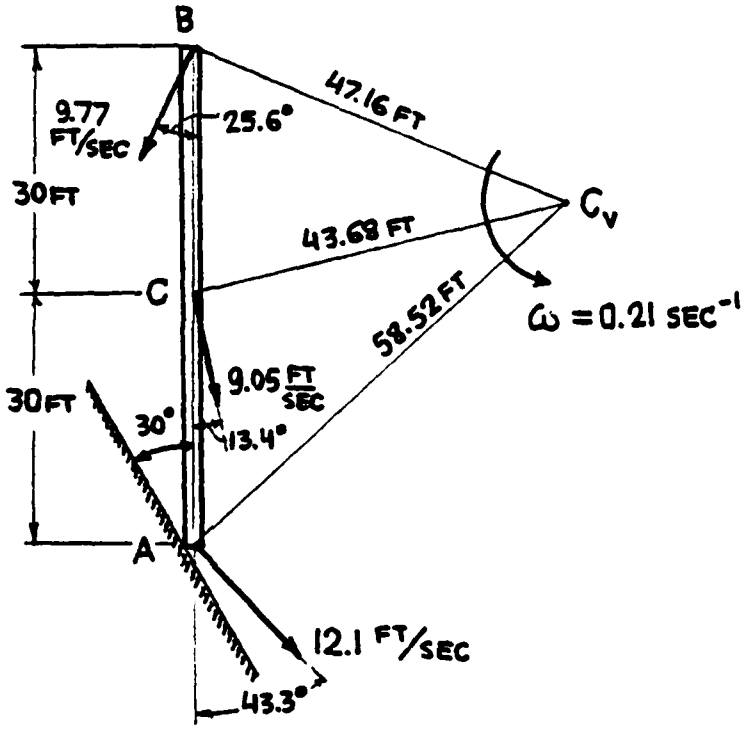


FIGURE 5.6 VELOCITY DISTRIBUTION ALONG THE REENTRY SUB AFTER THE IMPACT AND LOCATION OF THE INSTANTANEOUS CENTER OF VELOCITIES C_v

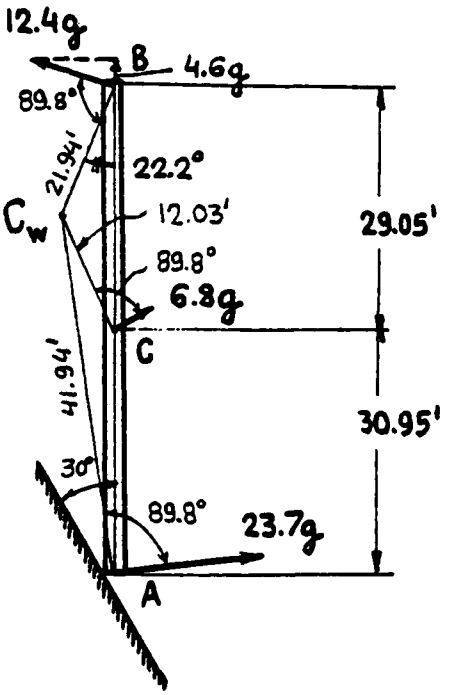


FIGURE 5.7 ACCELERATION DISTRIBUTION ALONG THE REENTRY SUB DURING THE IMPACT AND LOCATION OF THE INSTANTANEOUS CENTER OF ACCELERATIONS C_w

5.15 ELASTIC JOINT BETWEEN THE RS AND DP BY MEANS OF A SHOCK ABSORBER

Results of this analysis are described in detail in Appendix A.

5.16 BIP ISOLATION DURING THE REENTRY SUB IMPACT

This analysis in detail is provided in Appendix B and shows that two bushings located close to the ends of the BIP and made from 50 durameter rubber may reduce the dynamic loads applied to the BIP practically to zero.

5.17 REENTRY SUB MOTION AFTER THE IMPACT

This analysis was based on the assumption that the lower end of the RS after the impact would move along the reentry cone surface and the upper end - vertically. Justification of this assumption may be formulated on the results related to small angles φ of the RS rotation after the impact.

Detail analysis of this problem is described in Appendix C. Main results are:

- Maximum angle φ of the RS rotation after the impact is 6.7°,
- Maximum distance the lower end of the RS will move along the reentry cone generator is 14 FT,

- Angular velocity of the RS after the impact is in the range of 0.09-0.27 sec^{-1},
- Velocity of the lower end of the RS after the impact is defined in the range of 10.8-31 FT/SEC; velocity of the upper end is expected in the range of 9.35-28.7 FT/SEC; velocity of the center of mass - 9.74-28.8 FT/SEC,
- Angular acceleration of the RS motion after the impact is determined in the range of 0.26-0.28 SEC^{-2},
- Time duration of the RS motion along the reentry cone surface does not exceed 0.66 SEC,
- Acceleration of any point of the RS in motion after the impact is in vicinity of 1g,
- Dynamic horizontal force applied to the upper end of the RS is estimated in the range of 825-2,160 LBS; dynamic force applied to the lower end of the RS may be expected in the range of 1,865-3,360 LBS.

5.18 RESULTS, CONCLUSION AND RECOMMENDATIONS

Main results of this analysis are summarized in Section 4 "Summary of Results". In addition to this results short comments are as follows:

- Factual behavior of the RS during the impact may be expected between two extreme calculation schemes considered in this report,

- Actual mass involved in the reentry impact may be confined by the mass of the RS, since the mass of the DP involved in the impact is small compared with the RS mass,
- Crucial parameters of this analysis are: duration of the reentry impact and coefficient of restitution. These parameters are related to each other and recommended to be obtained experimentally,
- Impact force applied to the lower striking end of the RS is essentially dynamic and depends on many factors: mass, elastic and geometrical properties of the RS, reentry cone angle, contact stresses, connection between the RS and the DP,
- To decrease the impact energy and the contact stress applied to the striking end of the RS and reentry cone surface, an elastic component at the striking end of the RS is recommended to be installed,
- Shock absorber at the upper end of the RS 5.4 times decreases the impact force applied to the lower end of the drill pipe,
- Even in case of the worst dynamic loading, a simple isolation system may substantially reduce the forces applied to the BIP. Such a system is recommended for the designing.
- Considered mass-geometrical configuration of the

RS with the BIP, initial and boundary conditions and isolation system discussed enable to prevent the BIP installation and satisfy requirements related to dynamic loading occuring during the RS impact and its motion after the impact.

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APPENDIX A

REENTRY IMPACT ANALYSIS FOR ELASTIC JOINT BETWEEN THE REENTRY SUB AND DRILL PIPE BY MEANS OF AN ELASTIC SHOCK ABSORBER

A.1 REENTRY IMPACT ANALYSIS FOR ELASTIC JOINT BETWEEN THE REENTRY SUB AND DRILL PIPE BY MEANS OF AN ELASTIC SHOCK ABSORBER

Design requirements are described in Section 3 of this report. A shock absorber (isolator) located at the joint of the reentry sub and drill pipe (FIG. A.1) is considered to prevent the lower end of the DP from excessive loading due to reentry sub impact. Stiffness of the isolator is considered equal to 100,000 LBS/FT according to Reference 13. It is assumed that the isolator has a linear characteristic.

A.2 Technique developed in this report is applied here to evaluate the numerical results shown below:

v_x = 8.66 FT/SEC, v_y = -2.61 FT/SEC,
V_{ox} = 8.66 FT/SEC , V_{oy} = -5.0 FT/SEC,
ω = 0.20 SEC^{-1}, S = 1114.5 LBS.SEC,
V_x = 11.77 FT/SEC, V_y = 2.78 FT/SEC,
n = 1.4 SEC^{-1}, φ_{max} = 8.2°,
τ = 0.0072 SEC, F_{max} = 243 KIPS,
F_v = 122 KIPS, F_h = 211 KIPS.

A.3 Velocity distribution after the impact for the case under consideration is shown in FIG. 5.6. Results concerning the velocity distribution do not depend on the type of connection between the RS and DP. Distribution of the acceleration is provided in FIG. A.2.

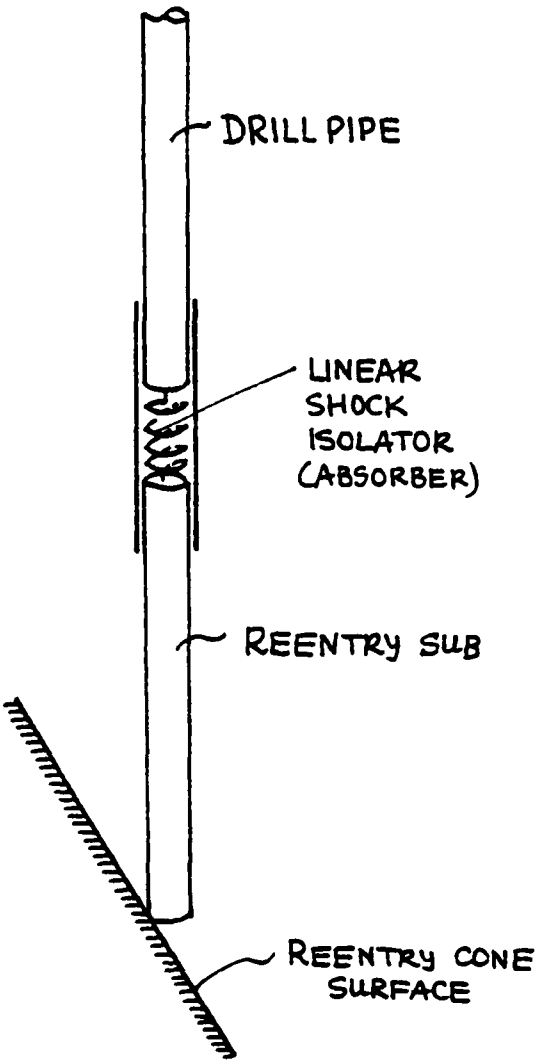


FIG. A.1

CALCULATION SCHEME

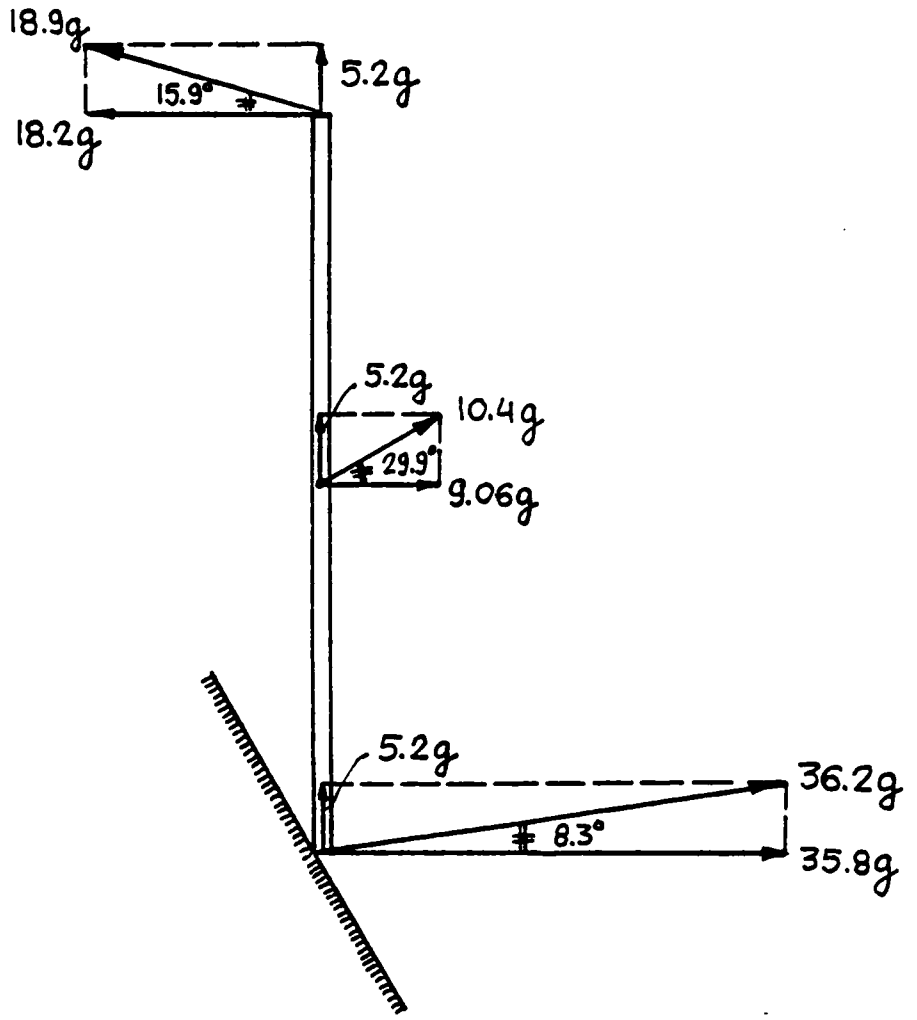


FIG. A.2

DISTRIBUTION OF ACCELERATIONS AND THEIR VERTICAL AND HORIZONTAL COMPONENTS DURING THE REENTRY IMPACT

A.4 Force applied to the lower end of the drill pipe due to the impact is determined as follows. For elastic joint:

$$G = C_1 \cdot \Delta V \cdot \tau = 100{,}000 \cdot 0.65 \cdot 0.0072 = 470 \text{ LBS}$$

For rigid joint:

$$G = Lmg\left(1 + \frac{\Delta V}{g\tau}\right) = 120 \cdot 16.4 \cdot \left(1 + \frac{0.65}{32.2 \cdot 0.0072}\right) = 2520 \text{ LBS},$$

where $\Delta V = 0.65$ FT/SEC denotes the difference in the vertical component of the RS velocity before and after the impact,

L = 120 FT is the conservative length of the DP which could be involved in the impact ($L = c\tau$ = 17000 . 0.0072 = 120 FT, C = sound velocity in steel, τ = time duration of the impact, 16.4 LBS/FT = dry weight of the drill pipe per unit length), C_1 denotes the stiffness of the elastic joint.

It is important to mention that the shock absorber can decrease the magnitude of the force under consideration 5.4 times.

If the stiffness of the shock absorber is 100,000 LBS/FT, then its maximum displacement will be in the range of $\lambda = 470 \cdot 12 / 100{,}000 = 0.06$ INCH.

APPENDIX B

BIP ISOLATION DURING THE

REENTRY SUB IMPACT

(The contents of this Appendix
was discussed in Reference II)

B.1 Horizontal components of the RS velocity at the levels of the upper A^1 and lower B^1 ends of the BIP (FIG. B.1) are 4.22 FT/SEC and 2.09 FT/SEC, respectively (See Section 5.14.2). Kinematically, the RS motion may be considered as a rotational motion with respect to the point E

$$e_1 = 10 \text{ ft}, \qquad e_2 = 20 \text{ ft}. \tag{1}$$

Horizontal components of the velocities $\vec{V}_1$ and $\vec{V}_2$ are:

$$V_1 = 2.09 \cdot \frac{a_1 - r}{e_1} \quad \text{(FT/SEC)}, \tag{2}$$

$$V_2 = 4.22 \cdot \frac{a_2 + r}{e_2} \quad \text{(FT/SEC)}. \tag{3}$$

Angular velocity of the RS rotation is

$$\dot{\psi} = 0.2 \quad \text{RAD/SEC}. \tag{4}$$

B.2 Isolators 1 and 2 (FIG. B.1) have nonlinear "hardening" characteristic (FIG. B.2), i.e. the slope of the curve respresenting spring force vs. deflection increases with increasing deflection. The shape factor is 1.1 (Reference 12).

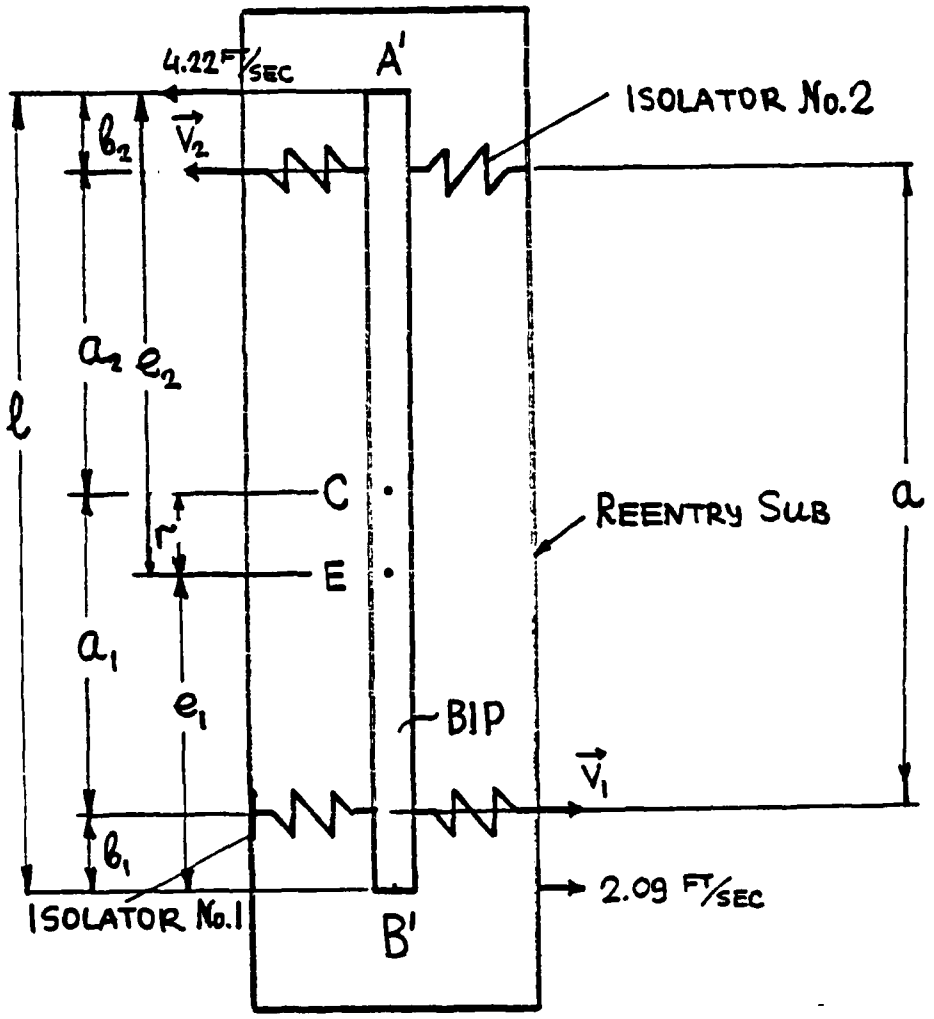


FIG. B.1

CALCULATION SCHEME

(NUMERICAL INPUT according to Reference 12:

$a_1 = 11.25$ FT, $a_2 = 10.83$ FT, $r = 4.17$ FT, BIP dry weight is 3300 LBS, $\ell = 26.7$ FT, $b_1 = 2.08$ FT, $b_2 = 2.5$ FT)

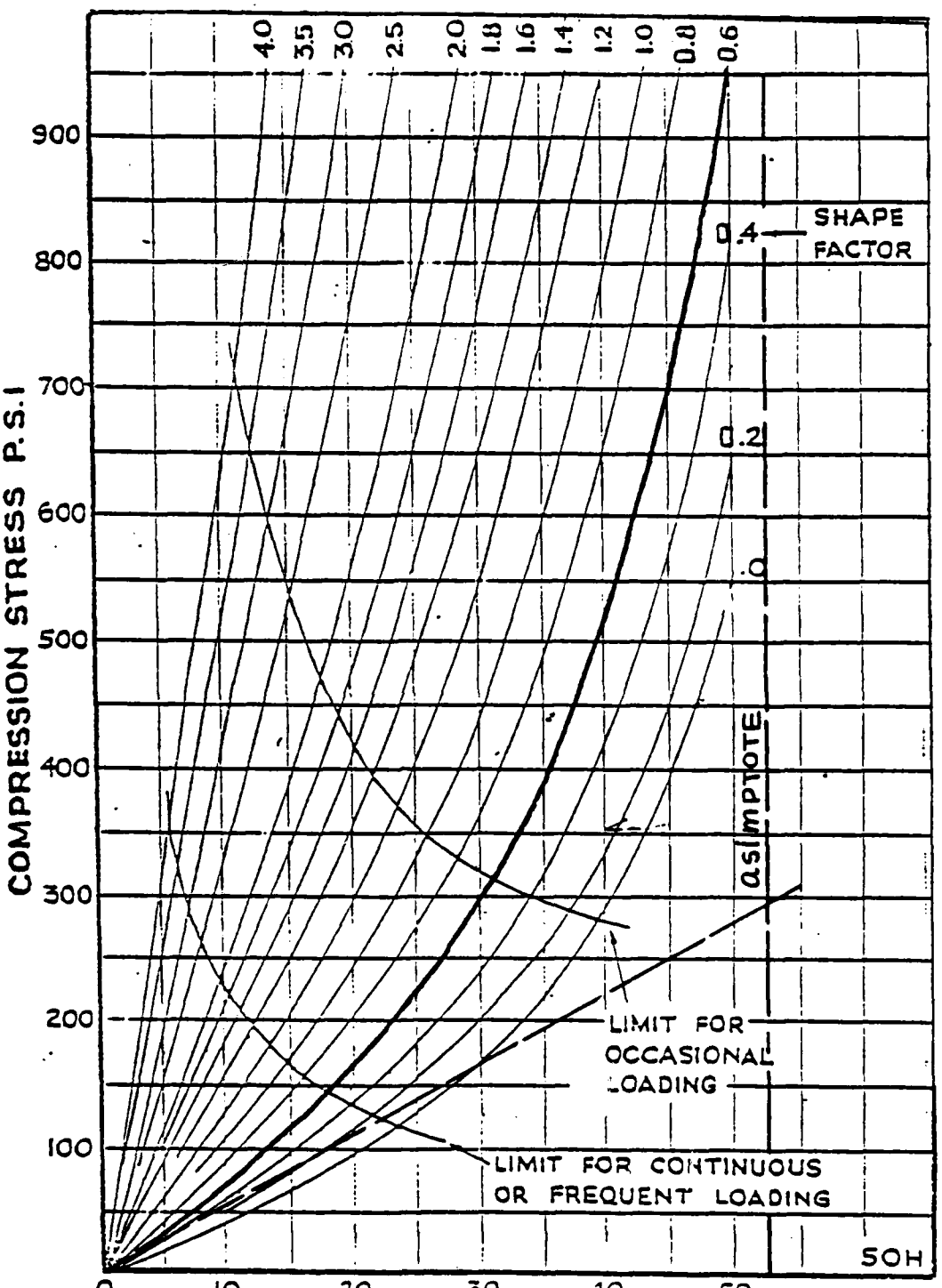


FIG. B.2. Compression Stress-Strain Curves for 50 Durometer Rubber

(REFERENCE 10)

According to Reference 10, the hollow cylinder of rubber may be represented by four equal blocks as shown in FIG. B.3.

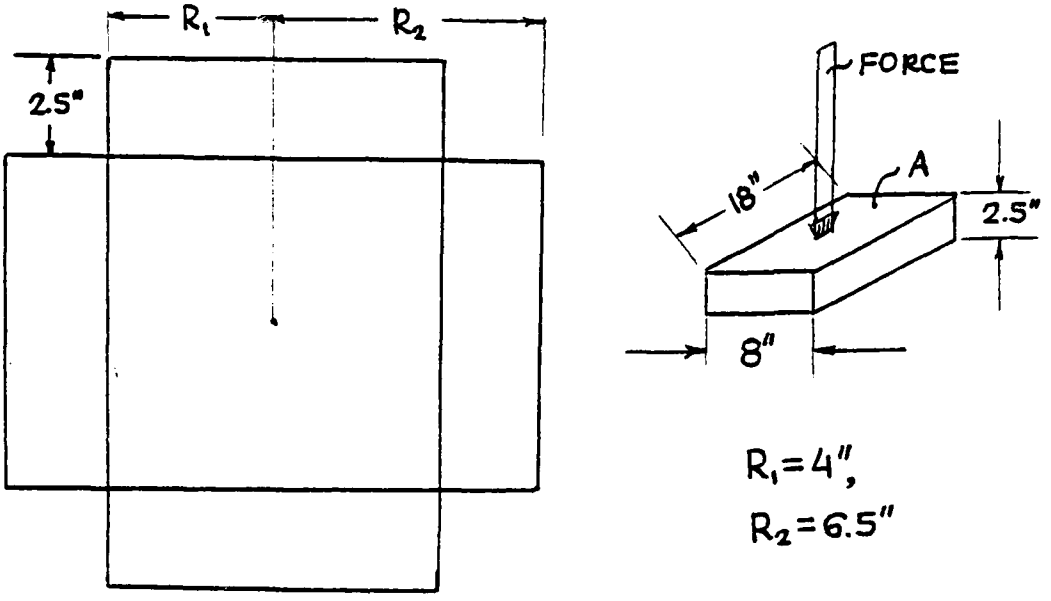


FIG. B.3 SCHEME FOR COMPUTATION

The combined stiffness may be calculated as follows:

$$K_* = 1.5\,K\,, \tag{5}$$

where K is the stiffness of the compressed block Evaluate K . Total maximum force applied to the upper isolator will not exceed

$$F_{max} = \frac{3300}{2\cdot g}\cdot 11g = 18150 \text{ LBS}, \tag{6}$$

where $11g$ is the horizontal component of the acceleration at the level of the upper isolator (FIG.5.7, page 28). Loaded area A is (FIG. B.3):

$$A = 8 \cdot 18 = 144 \text{ IN}^2. \tag{7}$$

Consequently, maximum expected stress will be not more than

$$\sigma = \frac{F_{max}}{A} = \frac{18150}{144} = 126 \text{ psi}. \tag{8}$$

From FIG. B.2 for the shape factor 1.1 one can obtain maximum compressive deflection 0.12% or

$$\delta_{max} = 0.12 \cdot 2.5 = 0.3 \text{ INCH}. \tag{9}$$

In this range the rubber isolator behaves like a linear spring with (from FIG. B.2)

$$K = \frac{126}{0.3} = 420 \text{ LBS/IN}^3. \tag{10}$$

If one takes into consideration relation (5), then

$$K_s = 1.5 \cdot 420 = 630 \text{ LBS/IN}^3. \tag{11}$$

Restoring force of one isolator is

$$F = K_s A \delta = 7560\,\delta \quad \text{LBS}, \tag{12}$$

where deflection δ must be measured in FT.

B.3 BIP on the isolators is an elastically supported system. Natural frequency of it with respect to the center of mass is:

$$p = \sqrt{\frac{7560\,(a_1+a_2)}{J_c}}\,, \tag{13}$$

where J_c denotes the mass moment of inertia of the BIP with respect to its center of mass, and a_1 and a_2 are displayed in FIG. B.1. Consider $a_1 = 11.25$ FT, $a_2 = 10.83$ FT, $J_c = 7693$ LBS.FT.SEC^2, then

$$p = 4.65 \text{ sec}^{-1}. \tag{14}$$

B.4 Maximum angular acceleration of the BIP after the shock (Reference 2, page 31-7) is:

$$\varepsilon_{max} = p^2 \varphi_{max}\,, \tag{15}$$

where φ_{max} is the maximum angular rotation of the RS with respect to the BIP

$$\varphi_{max} = \frac{\delta_{max}}{e_2 - b_2} = \frac{0.3}{(20-2.5)\cdot 12} = 0.0015 \text{ radian}. \tag{16}$$

Consequently,

$$\varepsilon_{max} = 4.65^2 \cdot 0.0015 = 0.033 \text{ sec}^{-2} \tag{17}$$

B.5 Linear accelerations along the BIP are proportional to the distance X (FIG. B.4)

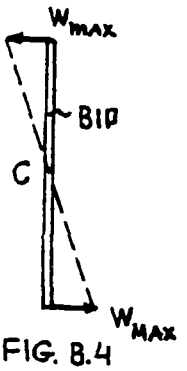


FIG. B.4

between the center of the BIP mass and and the point under consideration

$$W_{max} = \frac{l}{2} \cdot \varepsilon_{max} =$$

$$= 15.0.033 = 0.5 \text{ FT/SEC}^2 =$$

$$= 0.02\, g \qquad (18)$$

B.6 CONCLUSION

The isolation system designed will reduce the horizontal component of the acceleration practically to zero. This report shows that the vertical component of the acceleration during the impact is small.

APPENDIX C

REENTRY SUB MOTION AFTER THE IMPACT

C.1 MATHEMATICAL FORMULATION

Assuming that the upper end of the RS moves vertically and the lower end does along the reentry cone surface (FIG. C.1), determine the distribution of velocities and accelerations as well as the relationship between the RS disposition and forces $\vec{N}_B$ and $\vec{N}_A$ applied to the upper and lower end of the RS, respectively.

C.2 ASSUMPTIONS

- water influence is neglected,
- surface of the reentry cone is rigid,
- there is no energy lost during the impact,
- vertical component of the force applied to the upper end of the RS can be neglected.

C. 3 ENERGY CONSERVATION THEOREM

Is applied to obtain the velocity of the center of mass after the impact

$$T_1 - T_0 = W, \tag{1}$$

where T_1 = kinetic energy of the RS after the impact,

T_0 = kinetic energy before the impact,

W = work done by acting forces.

Consequently,

$$T_1 = \frac{Mv_c^2}{2} + \frac{J_c\omega^2}{2}, \quad T_0 = \frac{Mv_0^2}{2}, \quad W = Ph, \tag{2}$$

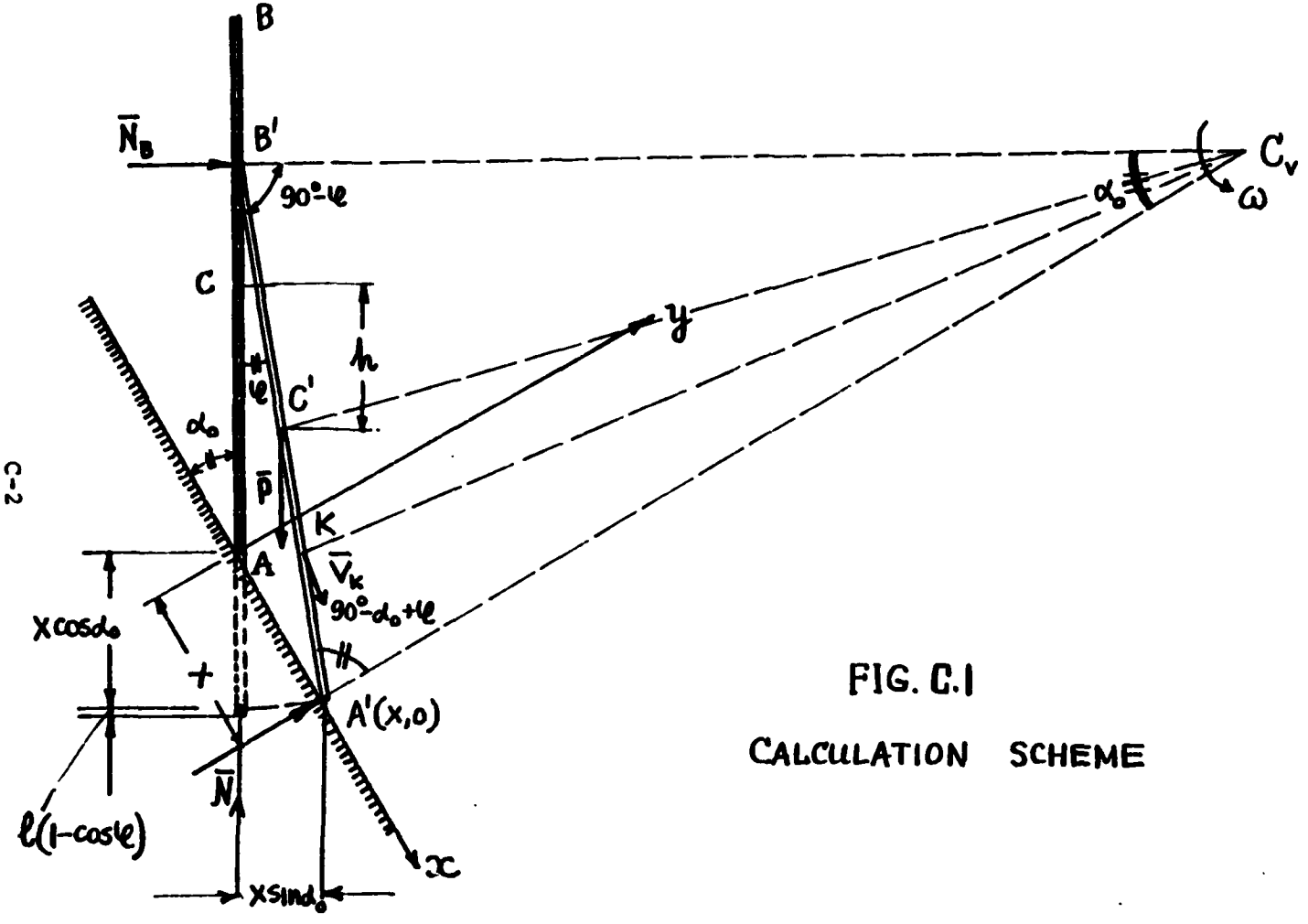


FIG. C.1

CALCULATION SCHEME

where M = RS mass,

J_c = RS mass moment of inertia with respect to its center of mass,

V_c = velocity of the center of mass after the impact,

ω = angular velocity after the impact,

p = RS wet weight,

h = displacement of the center of mass (FIG.C.1),

V_0 = RS velocity before the impact.

C.4 GEOMETRICAL RELATIONS USED IN CALCULATIONS

$$h = \ell\left[\sin\varphi\cdot\cot\alpha_0 + 0.5(1-\cos\varphi)\right],$$

$$x = \ell\cdot\sin\varphi\cdot\csc\alpha_0,$$

$$\varphi = \sin^{-1}\left(\frac{x}{\ell}\sin\alpha_0\right),$$

$$A'C_v = \ell\cdot\cos\varphi\cdot\csc\alpha_0,$$

$$C'C_v = \ell\sqrt{0.25+\cos^2\varphi\cdot\csc^2\alpha_0 - \cos\varphi\cdot\sin(\alpha_0-\varphi)\csc\alpha_0},$$

$$B'C_v = \ell\cdot\cos(\alpha_0-\varphi)\cdot\csc\alpha_0.$$

Here C_v denotes the instanteneous center of velocities of the RS after the impact (FIG. C.1).

TABLE C.1 contains numerical information about x and φ for the RS motion after the impact. Analogous information about distances between points A,B and C and the instantaneous center of velocites may be found in Table C.2.

TABLE C.1 NUMERICAL CORRELATION BETWEEN x AND φ (FIG. C.1)

x FT	0	2	4	6	8	10	12	14
φ Degrees	0	0.95	1.91	2.87	3.82	4.78	5.74	6.70

TABLE C.2 DISTANCES BETWEEN POINTS A,B AND C AND THE INSTANTENEOUS CENTER OF VELOCITIES

x FT	0	2	4	6	8	10	12	14
B^1C_v FT	103.92	104.90	105.87	106.80	107.69	108.56	109.40	110.21
C^1C_v FT	108.17	108.66	109.00	109.49	109.82	110.15	110.47	110.80
A^1C_v FT	120.00	120.00	119.93	119.85	119.73	119.58	119.40	119.18

C.5 KINEMATICAL RELATION BETWEEN V_c AND ω

From equation

$$V_c = C'C_v \cdot \omega$$

one can obtain

$$V_c = \ell\omega\left[F(\varphi)\right]^{1/2} \text{ or}$$

$$\omega = \frac{1}{\ell}\sqrt{\frac{V_o^2 + 2g\ell\left[\sin\varphi\cot\alpha_o + 0.5(1-\cos\varphi)\right]}{\frac{1}{12} + F(\varphi)}} \quad (\text{sec}^{-1}),$$

where

$$F(\varphi) = 0.25 + \cos^2\varphi \cdot \csc^2\alpha_o - \cos\varphi \cdot \sin(\alpha_o - \varphi)\csc\alpha_o .$$

Angular velocity ω is provided in Table C.3 for various X and angles φ.

TABLE C.3 ANGULAR VELOCITY OF THE RS MOTION AFTER THE IMPACT

x FT	0	2	4	6	8	10	12	14
ω SEC^{-1}	0.09	0.13	0.16	0.19	0.21	0.23	0.25	0.27

C.6 VELOCITY DISTRIBUTION ALONG THE RS AFTER THE IMPACT

This distribution is found in accordance with the relation

$$V_k = KC_v \cdot \omega,$$

where K denotes any point at the RS. This distribution for three main points A,B and C is shown in Table C.4.

TABLE C.4 VELOCITY DISTRIBUTION ALONG THE RS IN MOTION AFTER THE IMPACT FOR 3 POINTS (FIG. C.1)

x FT	0	2	4	6	8	10	12	14
V_A FT/SEC	10.8	15.6	19.2	22.8	25.1	27.5	29.8	31.0
V_B FT/SEC	9.35	13.6	16.9	20.3	22.6	25.0	27.3	28.7
V_C FT/SEC	9.74	14.1	17.4	20.8	23.1	25.3	27.6	28.8

C.7 ANGULAR ACCELERATION OF THE REENTRY SUB IN MOTION AFTER THE IMPACT

This acceleration may be obtained by differentiating the relation for ω (Section 5 of this Appendix). The final result is as follows:

$$\varepsilon = \frac{2g(\cos\varphi \cdot \cot\alpha_0 + 0.5\sin\varphi) - l\omega^2 F_1(\varphi)}{2l\,[0.5 + F(\varphi)]} \quad (sec^{-2}),$$

where $$F_1(\varphi) = \frac{1}{\omega}\dot{F}(\varphi) = -\sin 2\varphi \csc^2\alpha_0 + \cos(\alpha_0 - 2\varphi)\csc\alpha_0.$$

Table C.5 confines the value of ε for the RS motion after the impact.

TABLE C.5 ANGULAR ACCELERATION OF THE RS IN MOTION AFTER THE IMPACT

x FT	0	2	4	6	8	10	12	14
ε SEC^{-2}	0.28	0.27	0.27	0.27	0.27	0.27	0.26	0.26

C.8 TIME DURATION OF THE RS MOTION ALONG THE REENTRY CONE SURFACE

Table C.5 shows that after the impact the RS will move with almost constant angular acceleration. Knowing the angular velocity (Table C.3), one can get the time duration of the RS motion after the impact along the Reentry cone surface. This information is provided in Table C.6.

TABLE C.6 TIME DURATION OF THE RS MOTION ALONG THE REENTRY CONE SURFACE

X FT	0	2	4	6	8	10	12	14
t SEC	0	0.15	0.11	0.11	0.07	0.07	0.07	0.08

Total time duration of the motion along the reentry cone surface will not exceed 0.66 SEC.

C.9 ACCELERATION DISTRIBUTION ALONG THE RS IN MOTION AFTER THE IMPACT

This distribution is found by means of the method based on the instanteneous center of accelerations (point C_w FIG. C.2). To obtain this point two vectors $\vec{W}_A$ and $\vec{W}_B$ were rotated by the angle.

$$\mu = \tan^{-1} \frac{|\varepsilon|}{\omega^2}$$

In direction of the angular acceleration ε. The intersection of this two lines is the point C_w. For any point K the absolute value of the acceleration is

$$W_K = KC_w \cdot \sqrt{\varepsilon^2 + \omega^4}.$$

Table C.7 provides the information concerning the distances between the instanteneous center of accelerations and three points at the RS. Accelerations are provided in Table C.8.

TABLE C.7 DISTANCES BETWEEN C_w AND POINTS A,B AND C OF THE REENTRY SUB AND ANGLE μ

$\frac{x}{FT}$	0	2	4	6	8	10	12	14
$\frac{BC_w}{FT}$	105.66	108.35	110.71	113.10	114.83	116.37	117.89	118.95
$\frac{CC_w}{FT}$	108.98	110.11	110.96	111.61	111.90	111.95	111.66	111.03
$\frac{AC_w}{FT}$	119.95	119.62	119.02	118.00	116.87	115.42	113.30	110.94
μ Degrees	88.3	86.4	84.6	82.4	80.7	78.9	76.5	74.3

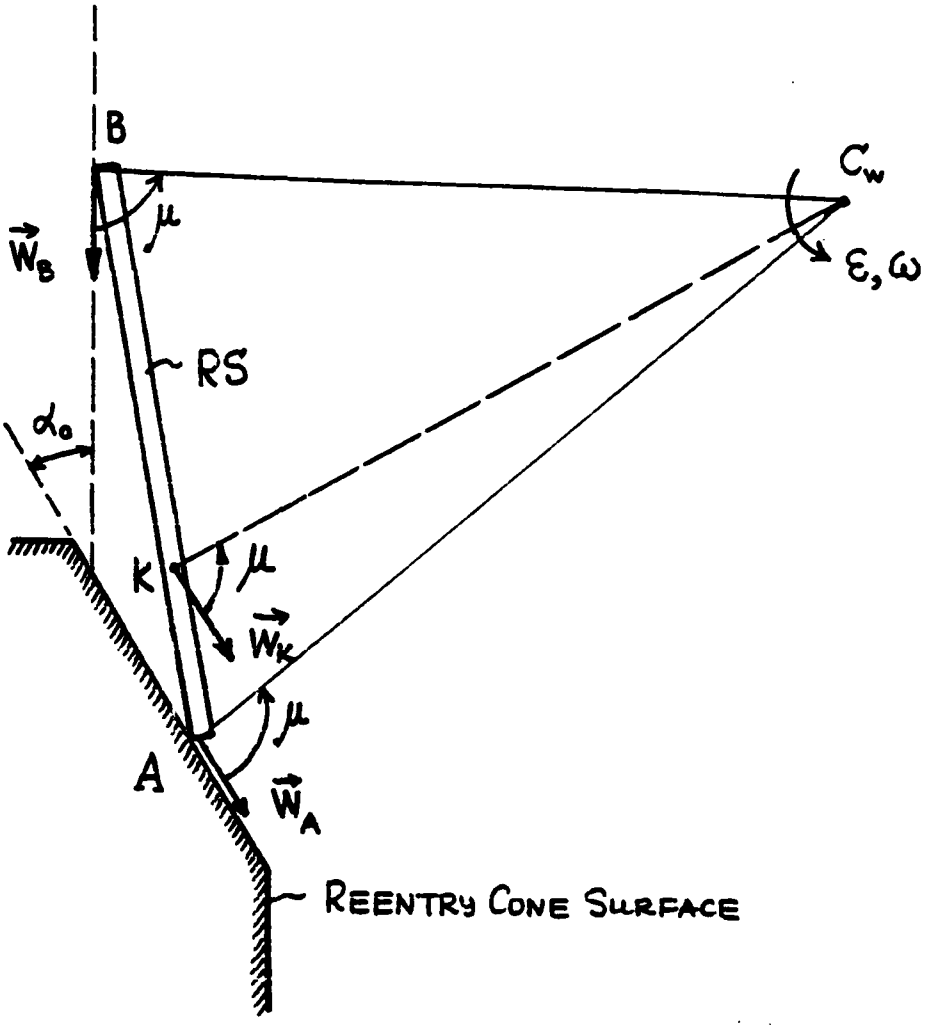


FIG. C.2

INSTANTENEOUS CENTER OF ACCELERATIONS OF THE RS IN MOTION AFTER THE IMPACT

TABLE C.8 ACCELERATIONS OF THREE POINTS A,B AND C OF THE RS IN MOTION AFTER THE IMPACT

x FT	0	2	4	6	8	10	12	14
W_B FT/SEC^2	29.0	29.3	29.9	30.5	31.0	31.4	31.8	32.1
W_C FT/SEC^2	30.5	29.7	30.0	30.1	30.2	31.3	30.1	30.0
W_A FT/SEC^2	32.2	32.2	32.1	31.9	31.5	32.3	30.6	30.0

C.10 FORCES $\vec{N}_B$ AND $\vec{N}_A$ APPLIED TO THE ENDS OF THE RS IN MOTION AFTER THE IMPACT (FIG. C.3)

Denote $\ddot{\xi}_c$ adn $\ddot{\eta}_c$ horizontal and vertical components of the acceleration vector of the center of mass C. Then apply the theorem of the center mass motion of a mechanical system

$$M\ddot{\xi}_c = N_B + N_A \cos\alpha_0,$$

$$M\ddot{\eta}_c = P - N_A \sin\alpha_0.$$

Since the vector of $\vec{W}_c$ is known, these relations may be used to obtain two unknown forces $\vec{N}_A, \vec{N}_B$ applied to both ends of the RS.

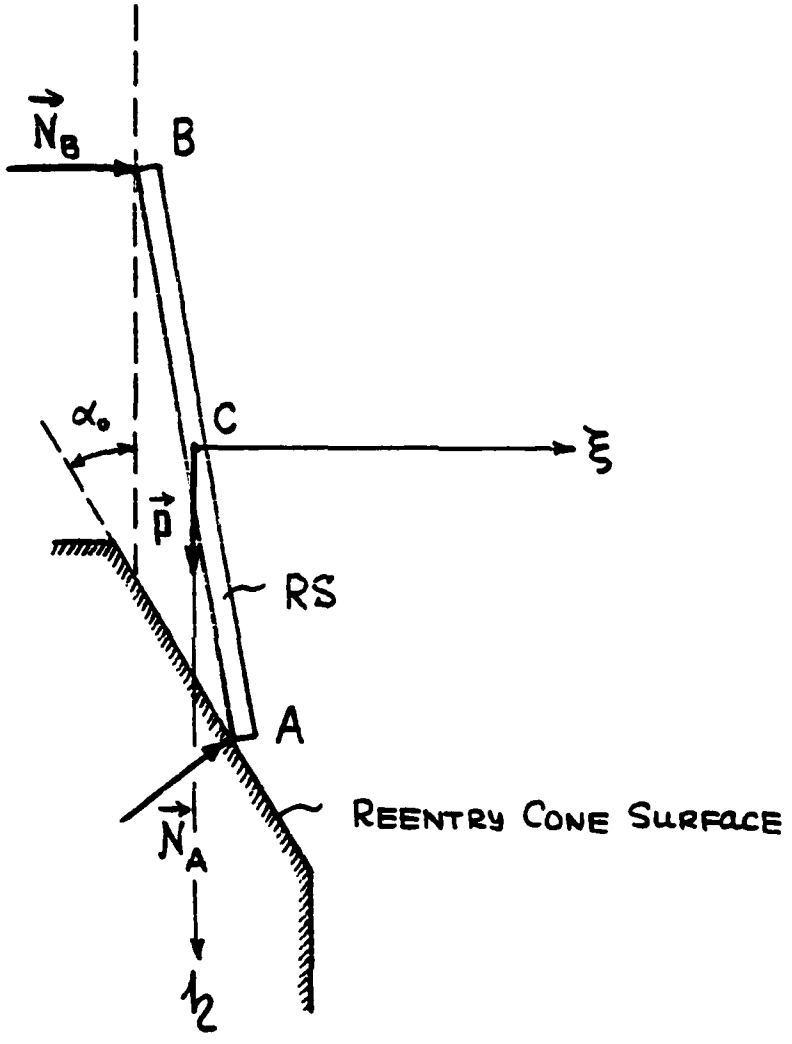


FIG. C.3

CALCULATION SCHEME FOR DETERMINING FORCES $\vec{N}_A$ AND $\vec{N}_B$ APPLIED TO BOTH END OF THE REENTRY SUB.

Results of calculation are presented in Table C.9.

TABLE C.9 DYNAMIC FORCES $\vec{N}_A$ AND $\vec{N}_B$ ACTING ON THE ENDS OF THE RS DURING THE MOTION ALONG THE REENTRY CONE SURFACE

x FT	0	2	4	6	8	10	12	14
N_B LBS	1574	823	1065	1146	1261	2161	1040	913
N_A LBS	2704	3357	3077	2984	2797	1865	2890	2984

APPENDIX F

DRILL STRING DYNAMIC ANAYLSIS REPORT

NOTE: This Appendix F contains two (2) Supplimental Appendices A and B.

RPT-001-002

MARINE SEISMIC SYSTEM
STATIC AND DYNAMIC BEHAVIOR
OF THE DRILL PIPE DURING
THE REENTRY SUB INSTALLATION

(Job 00001, Task 210200)

20 AUGUST 1980

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A "MSSOS" COMPUTER PROGRAM - THEORETICAL BASIC FORMULATION.

B. DAMPING EFFECT.

1.0 ABSTRACT

This report deals with the problem of the drill pipe (DP) behavior and stresses during the re-entry sub (RS) installation. Two types of forces applied to the DP are considered: static acting forces due to current and dynamic excitation due to ship motion. The analysis concerns the evaluation of the deflections, slope, bending moment and bending stress for various lengths of the DP. The range of the DP length under consideration is between 200 and 20,000 ft. Results are provided in tabulated and graphical forms and can be used to evaluate the DP behavior during RS installation for various sea state conditions. No attempt is made to corrolate results to available data or to those of the other comparable methods.

2.0 OBJECTIVES

The following objectives are considered in this report:

- provide information about the DP behavior due to current and various ship offset,
- evaluate the expected deflections and stresses due to ship motion,
- evaluate maximum stresses in the DP during the RS release and installation,
- consider various sea state conditions and their influence on the DP strength,

- determine restrictions on "GLOMAR CHALLENGER" operations due to sea state regarding the DP strength.

3.0 DESIGN REQUIREMENTS

The following design requirements are considered:

- DP length during installation varies in the range of $0 \leq \ell \leq 20000$ ft.
- DP diameter: outside - 5 inches, inside 4.125 inches,
- DP material - steel with modulus of elasticity of 30.10^6 psi,
- RS mass is 466 lbs.ft.sec^2, this corresponds to the dry weight of the RS of 15,000 lbs,
- RS length 60 ft,
- current velocity at the surface - 2kn,
- current velocity at the bottom - 0,
- current velocity follows the linear distribution law,
- installation will be performed by "GLOMAR CHALLENGER" (Reference 10).

4.0 SUMMARY OF RESULTS

Results of the investigation are summarized below:

- Maximum displacement of the lower end of the DP during installation due to current is 1,150 ft.

It corresponds to the DP length in the range of 8-10 thousand ft (FIG. 5.1).

- Displacement of the lower end of the DP due to current for the completely deployed pipe is 637 ft (FIG. 5.1)
- The deflected shape of the installed DP due to current depends on the ship's offset, FIG. 5.2 shows the deflected shapes for various ship offsets. Maximum displacement is 250 ft (corresponds to 0 offset), 640 ft (corresponds to 500 ft offset), 1,060 ft (corresponds to 1,000 ft offset). For these cases angles at the top are 3.3°, 2.6° and 2°, respectively. Angles at the lower end are 3°, 7° and 10°, respectively.
- Dead weight and current both cause bending stresses in the drill pipe. Numerical information is shown in Table 5.1. Maximum values of the total combined stress occur at the top end of the drill pipe and can be expected in the range of 640 to 54,000 psi depending on the deployed length of the DP.
- Bending stress due to current for the installed length more than 10,000 ft is small compared with axial stress due to dead weight. Its contribution decreases when the length of the DP is increased during installation (over 10,000 ft). For instance, for DP length of 10,000 ft, it is 15% of axial stress, for 20,000 ft it is only 1.5%.

- Previous conclusion confirms the assumption that the DP bending resistance is negligibly small. In other words, the drill pipe behaves like a string.
- Maximum combined static stress does not exceed 54,000 psi.
- Range of the natural frequencies of the DP in lateral oscillation is between 0.05 and 1.9 Sec^{-1} for the first 7 modes, (Table 5.2). It corresponds to the natural periods in the range of 3.3 till 125.6 sec, (Table 5.3).
- Ship sway motion for beam seas is the determining factor of dynamic excitation applied to the drill pipe, (FIG. 5.3).
- Maximum RMS of deflection due to ship sway motion depends upon sea state condition and installed length of the DP (Table 5.6).
- RMS bending stress due to ship sway motion depends on the same factors (sea state condition and length of the DP). Complete information is provided in Table 5.9. It does not exceed 3,336 psi for 16 ft significant wave.
- In case of no heave compensators ship heave motion does not cause dynamic stresses in the drill pipe, because of the free lower end.
- Combined RMS dynamic and static bending and axial stress does not exceed 57,370 psi; combined significant dynamic and static stresses are not more

than 60,700 psi, and the maximum combined stress in the pipe is 66,430 psi.

- Combined stresses in the drill pipe due to all sources of loading for any stage of the installation are less than the allowable stresses,
- As far as the strength of the drill pipe is concerned, the installation of the re-entry sub can be performed practically without restrictions connected with sea state conditions (within 16 ft significant wave height for random sea considered).

5.0 TECHNICAL DISCUSSION

5.1 COMPUTATIONAL METHODS AND COMPUTER PROGRAMS

The following computer programs were used in this study:

- TOWER,
- RISNL3D
- MSSOS,
- SPECTR.

Below, some information about these computer programs is described.

5.1.1 "TOWER" COMPUTER PROGRAM

This program has been used for static analysis of the DP due to drag forces generated by ocean current.

Analytical method employed in "TOWER" is given in details in Reference 2. The number of elements was varied from 10 to 200 depending on the deployed length of the DP. Loads and stresses reflected in this report correspond only to sections at which they accomplish their maximum values.

The output includes the values of deflection and stresses and their distribution along the pipe. The boundary conditions were modified in order to handle the DP deployment problem.

5.1.2 "RISNL3D" COMPUTER PROGRAM

This computer program is tailored for three dimensional nonlinear riser analysis when statically applied forces are considered. It is designed to determine loads and stresses subjected to specified environmental conditions. A system of nonlinear equations which model three dimensional riser system is given in details in Reference 1.

The output includes the values of deflection and bending stress along the DP for boundary conditions corresponding to both DP ends pinned.

This model and computer program were utilized for the maximum water depth for the completely deployed DP.

5.1.3 "MSSOS" COMPUTER PROGRAM

This program is designed to calculate displacement of the DP and dynamic stresses in it due to ship motion. Calculation model considers the DP as a heavy string with variable tension in it. The RS and BIP are simulated as a concentrated mass at the lower end of the drill pipe (FIG. A.1). The following assumptions were considered:

- DP is a homogeneous string
- Tension can be described by linear relationship.

Differential equation describing the DP dynamic behavior is reduced to Bessel differential equation and its solution was obtained in Bessel functions of the first and second order. Details of this analysis can be found in Appendix A. The computer program is described in Reference 12.

Damping effect was considered separately and then incorporated in the computer program for frequencies which are located in the vicinity of the natural frequencies of the system. Details of this analysis one can find in Appendix B.

5.1.4 "SPECTR" COMPUTER PROGRAM

Actual dynamic bending stresses were determined by means of computer program "SPECTR" (Reference 7). The RAO factors of the drill pipe and the sway RAO of "GLOMAR CHALLENGER" for beam seas (Reference 8) were combined with Bretschneider's sea energy spectrum for 4,8,12 and 16 ft significant wave height for random sea condition. Bending stresses reported herin correspond to such sections of the DP where the bending stresses have their maximum values.

5.2 STATIC RESPONSE OF THE DP

This section contains results of static behavior of the DP during deployment. Analysis was performed for linear current profile with 2 kn at the surface and 0 at the ocean floor. The following deployed lengths of the DP were considered: 200,500, 1,000, 5,000, 10,000 and 20,000 ft. The drag coefficient C_D ent was determined according to Reference 4, its value of 1.0 was accepted.

5.2.1 DEFLECTED SHAPE

Deflected shape of the DP during installation can be characterized by the displacement of the lower end.

This displacement as a function of the deployed length is shown in FIG. 5.1. Maximum displacement corresponds to the DP length in the range of 8,000-10,000 ft. Then, this displacement decreases and for the whole deployed DP it does not exceed 637 ft. Once the DP is in place, the deflected shape changes due to ship offset. This relation is displayed in graphical from in FIG. 5.2.

5.2.2 BENDING STRESSES

Total stresses in the DP are caused by tension and bending. Maximum stress due to tension (own weight) occurs at the top end of the DP and decreases uniformly along the DP. Maximum bending stress depends upon curvature of the DP deflected shape. Combined stresses are the sum of these two components. They are calculated with some conservatism because it was assumed that both items of stress are equal to their maximum values at the same points. Results are shown in Table 5.1. Comparison of the bending stress components shows that the contribution of stress due to bending is small and decreases with the deployed length of the DP. This result can be interpeted as follows: during deployment the drill pipe behaves like a beam with very low rigidity, i.e. in other words, like a heavy catenary or string.

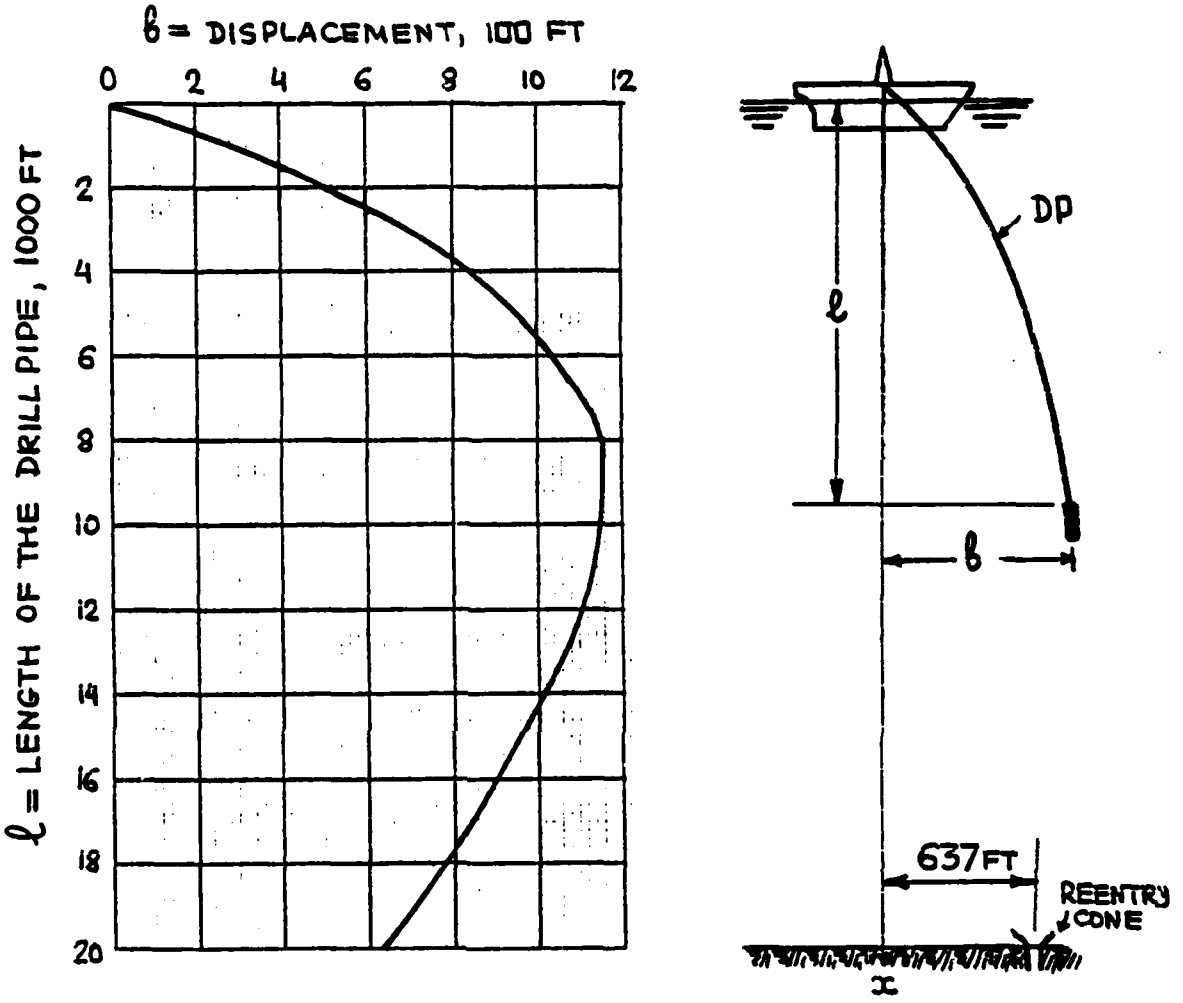


FIG. 5.1

DISPLACEMENT OF THE LOWER END OF THE DRILL PIPE (DP) AS A FUNCTION OF THE SUBMERGED LENGTH OF IT FOR LINEAR CURRENT PROFILE WITH 2 KN CURRENT AT THE SURFACE AND 0 AT THE OCEAN FLOOR.

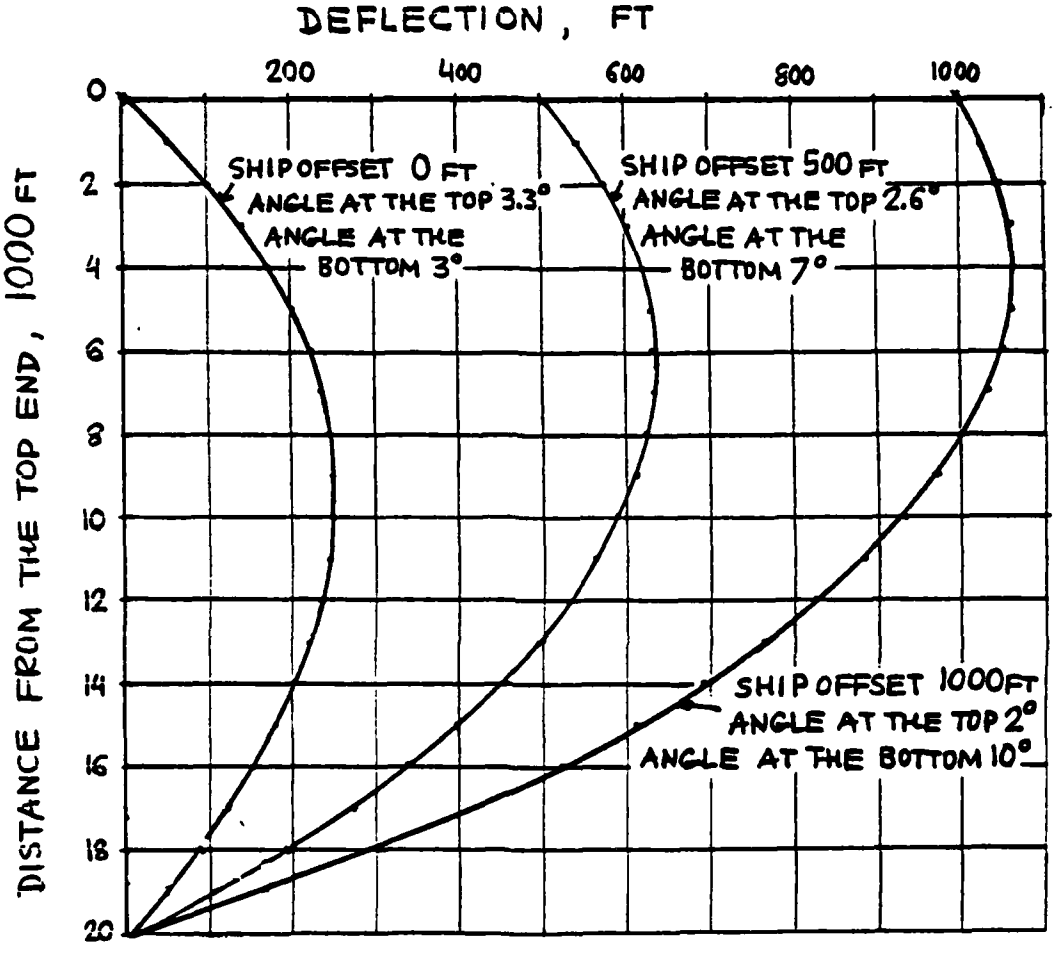


FIG. 5.2

DRILL PIPE DEFLECTION DUE TO 2 KN CURRENT AT THE SURFACE FOR THE TOP TENSION OF 400 KIPS AND VARIOUS SHIP OFFSET.

Table 5.1 MAXIMUM STRESS DUE TO TENSION AND CURRENT

DRILL PIPE LENGTH FT	MAXIMUM AXIAL STRESS PSI	MAXIMUM BENDING STRESS PSI	MAXIMUM COMBINED STRESS PSI
200	533	105	638
500	1332	1344	2676
1000	2664	1274	3938
5000	13317	9171	22488
10000	26635	4104	30739
20000	53269	764	54033
20000 *	53269	362	53631

* Ship offset = 1000 ft, boundary conditions correspond to pinned ends.

5.3 DYNAMIC RESPONSE OF THE DP

Dynamic analysis of the drill pipe includes natural frequencies and periods, deflected shape, slope and bending moment (stress) due to ship surge/sway motion. For forced oscillation of the DP the extreme motion corresponds to beam seas. Therefore, sway motion is the governing criteria for the dynamic behavior of the DP.

5.3 NATURAL FREQUENCIES IN LATERAL OSCILLATION

The calculation model for the lateral natural oscillation of the DP corresponds to a homogeneous heavy catenary. The upper end of the DP is considered to be pinned, the lower end - free with a concentrated mass at it. This concentrated mass simulates the re-entry sub with the BIP in it. Natural frequency equation is expressed by means of Bessel functions of the first and second kind of zero and first order and was solved numerically. Results are presented in Table 5.2 and correspond to a very wide range of the DP length during deployment (1,000 ft to 20,000 ft)

Table 5.2 RANGE OF NATURAL FREQUENCIES OF THE DP IN LATERAL OSCILLATION DURING DEPLOYMENT

Number of natural mode	Symbol	FREQUENCY, SEC^{-1}	
		Lower limit (for 20000 ft)	Upper limit (for 1000 ft)
1	ω_1	0.05	0.22
2	ω_2	0.11	0.49
3	ω_3	0.17	0.78
4	ω_4	0.24	1.06
5	ω_5	0.30	1.34
6	ω_6	0.36	1.62
7	ω_7	0.43	1.90

5.3.2 PERIODS OF NATURAL OSCILLATION

Periods of natural lateral oscillation are related to the appropriate frequencies. They are calculated for the same variable DP length and provided in Table 5.3. As one can see wave periods belong to the range of these periods. Consequently, wave excitation generates ship sway or surge motion with periods less or equal to the drill pipe natural periods. That is why ship motion has a dynamic character and can cause dynamic stresses in the drill pipe.

TABLE 5.3 RANGE OF THE PERIODS OF NATURAL LATERAL OSCILLATION OF THE DP DURING DEPLOYMENT

Number of natural mode	Symbol	PERIOD, SEC	
		Lower limit (for 1000 ft)	Upper limit (for 20000 ft)
1	T_1	28.5	125.6
2	T_2	12.8	57.1
3	T_3	8.0	36.9
4	T_4	5.9	26.2
5	T_5	4.7	20.9
6	T_6	3.9	17.4
7	T_7	3.3	14.6

5.3.3 DP DEFLECTION

RMS deflection values are determined by using MSSOS computer program (Appendix A). This program was used to obtain the RAO factors due to a unit ship excitation applied to the upper end of the DP. Then, this information was combined with response amplitude operators of "GLOMAR CHALLENGER" (FIG. 5.3) (Reference 8) and random sea spectrum. Bretschneider's sea spectrum for 4,8,12 and 16 ft significant wave height was used. Results are provided in Tables 5.4 through 5.6.

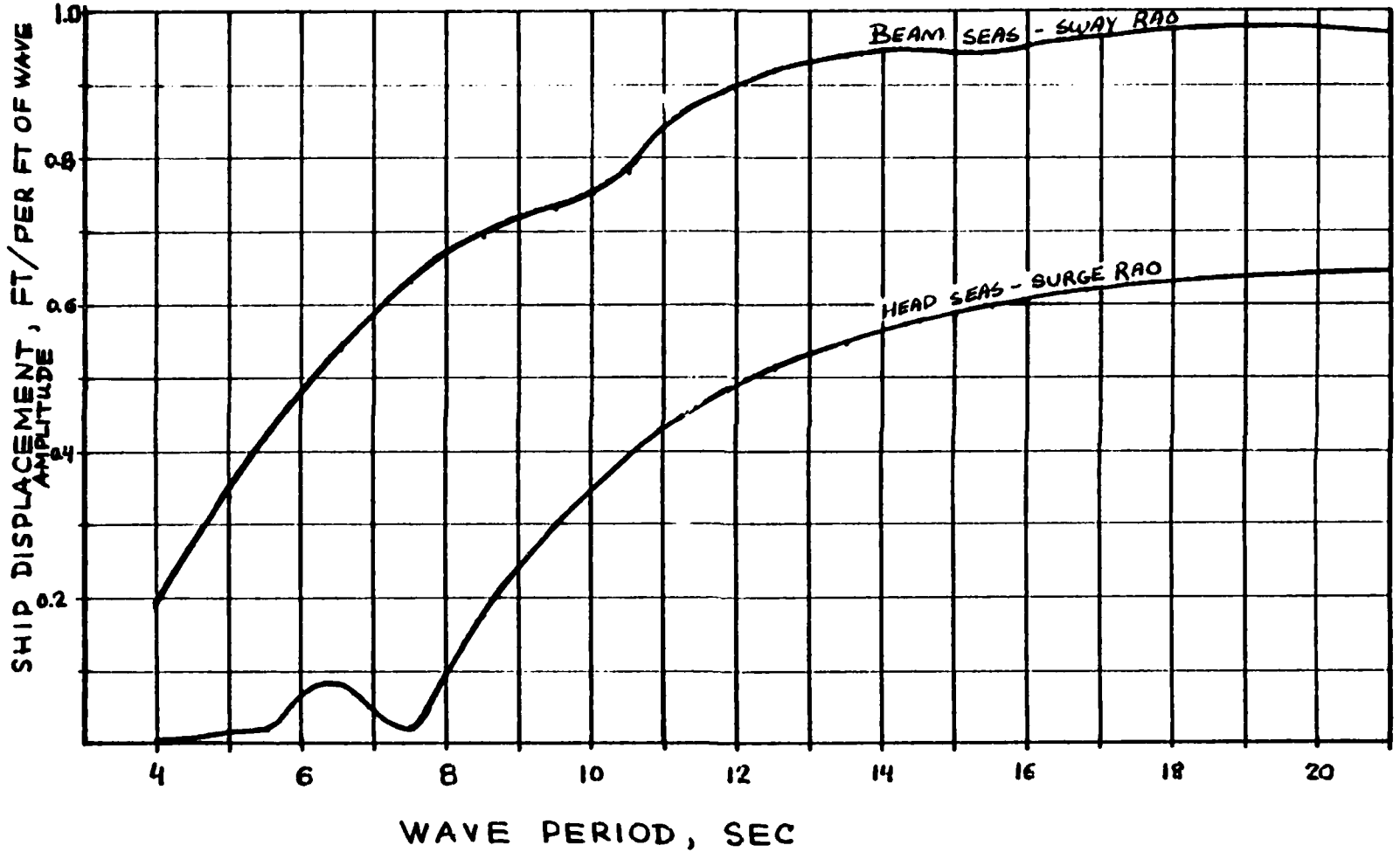


FIG. 5.3 "GLOMAR CHALLENGER" RESPONSE AMPLITUDE OPERATORS FOR SWAY AND SURGE MOTION.

TABLE 5.4 MAXIMUM VALUES OF THE RAO OF DEFLECTION FOR DRILL PIPE DUE TO SHIP SURGE OR SWAY MOTION FOR VARIOUS LENGTH OF THE PIPE

Wave Frequency Sec^{-1}	Drill Pipe RAO Deflection, Ft/ft of ship Motion For Various Length Of The DP In Ft						
	200	500	1000	5000	10000	20000	Installed Pipe
0.449	1.0	1.0	1.5	1.44	5.65	7.06	4.0
0.483	1.0	1.0	5.25	1.67	2.77	2.15	2.3
0.524	1.0	1.0	8.41	6.9	1.71	9.13	2.3
0.571	1.0	4.24	1.59	1.59	2.77	8.67	3.2
0.628	1.5	1.64	1.13	2.27	4.6	0.22	4.0
0.698	1.0	1.0	1.67	0.30	0.24	0.22	6.0
0.785	1.0	5.9	0.96	2.27	2.62	3.06	2.8
0.898	4.0	1.5	1.69	1.99	1.53	1.74	2.0
1.047	1.0	1.5	5.04	0.33	0.23	8.1	14.5
1.257	1.2	0.95	0.55	1.41	1.91	6.89	5.0
1.571	1.0	1.1	1.64	3.01	2.60	4.10	3.7

TABLE 5.5 MAXIMUM RAO OF DEFLECTION OF THE DRILL PIPE DURING INSTALLATION FOR VARIOUS WAVE FREQUENCIES AND SHIP SWAY MOTION.

Wave Frequency Sec^{-1}	Ship Sway RAO Ft/Ft	Maximum RAO Deflection in Ft/Per Ft of Wave Amplitude for Various Length of the DP in Ft						
		200	500	1000	5000	10000	20000	Installed Pipe
0.449	0.9416	0.9416	0.9416	2.1186	1.356	5.320	6.648	3.77
0.483	0.9347	0.9347	0.9347	4.907	1.561	2.589	2.010	2.15
0.524	0.9174	0.9174	0.9174	1.458	6.330	1.569	8.376	2.11
0.571	0.8529	0.8529	3.616	1.356	1.356	2.363	7.395	2.73
0.628	0.7560	1.134	1.240	0.848	1.703	3.451	0.166	3.02
0.698	0.7203	0.7203	0.7203	1.203	0.220	0.050	0.159	4.32
0.785	0.6709	0.6709	3.958	0.647	1.635	1.887	2.204	1.88
0.898	0.5936	2.3744	0.890	1.003	1.181	0.908	1.033	1.19
1.047	0.4866	0.4866	0.730	2.452	0.161	0.111	3.941	7.06
1.257	0.3485	0.4182	0.331	0.192	0.686	0.929	3.353	1.74
1.571	0.1972	0.1972	0.2169	0.323	0.594	0.513	0.809	0.73

TABLE 5.6 MAXIMUM RMS OF DEFLECTION DUE TO SHIP SWAY MOTION AND VARIOUS SEA STATE CONDITIONS

Significant Wave Height, FT	Maximum RMS in Ft. for DP Length in Ft.						
	200	500	1000	5000	10000	20000	Installed Pipe
4	1.86	2.77	2.02	1.53	1.79	3.93	5.78
8	4.09	8.32	4.58	7.30	7.63	14.83	12.54
12	5.91	12.69	10.78	18.43	12.61	31.30	17.33
16	7.63	15.35	20.26	26.78	18.02	43.28	21.48

5.3.4 DP BENDING STRESSES DUE TO SHIP SWAY MOTION

RMS values of dynamic bending stresses are determined by employeing the same procedure which was used for determining deflections. Results from MSSOS computer program are combined with "GLOMAR CHALLENGER" RAO factors and then with BRETSCHNEIDER'S spectrum for different significant wave height. Intermediate and final results are shown in Tables 5.7 through 5.9.

TABLE 5.7 MAXIMUM VALUE OF RAO FOR BENDING STRESSES DUE TO SHIP MOTION FOR VARIOUS LENGTH OF THE DP

Wave Frequency Sec^{-1}	RAO for Bending Stresses in PSI Per 1 ft of Ship Motion for the DP length in Ft					
	200	500	1000	5000	10000	20000
0.449	44.1	30.2	46.3	48.9	254	306
0.483	48.1	35.9	263	66.8	115	86
0.524	54.9	41.3	404	333	71	436
0.571	68.6	278	113	116	197	570
0.628	101	125	86.5	127	261	122
0.698	104	70.5	146	3.5	228	112
0.785	115	723	104.8	240	269	318
0.898	620	257	205	336	216	247
1.047	200	348	1200	132	145	1940
1.257	368	40.2	323	338	523	1840
1.571	447	545	729	1230	905	1660

TABLE 5.8 MAXIMUM RAO FOR BENDING STRESSES IN THE DRILL PIPE DURING INSTALLATION FOR VARIOUS WAVE REQUENCIES AND SHIP SWAY MOTION

Wave Frequency Sec-1	Ship Sway RAO FT/FT	Maximum RAO in PSI/PER 1 FT of Wave Amplitude for Various Length of the DP in Ft.					
		200	500	1000	5000	10000	20000
0.449	0.9416	41.52	28.49	43.60	46.04	239.16	288.13
0.483	0.9347	44.96	33.56	245.83	62.43	107.50	80.00
0.524	0.9174	50.36	37.89	370.63	305.49	65.13	400.00
0.571	0.8529	58.09	237.11	96.38	98.96	168.02	492.98
0.628	0.7560	76.36	94.50	65.40	96.01	197.32	92.23
0.698	0.7203	74.91	50.78	105.16	2.52	164.50	80.67
0.785	0.6709	77.15	485.06	70.30	161.02	180.47	213.35
0.898	0.5936	368.03	152.55	121.68	199.45	128.22	146.61
1.047	0.4866	97.32	169.33	583.92	64.23	70.56	944.00
1.257	0.3485	128.25	14.0	112.60	117.79	182.26	641.24
1.571	0.1972	88.14	107.48	143.76	242.56	178.47	327.35

TABLE 5.9 MAXIMUM RMS OF BENDING STRESSES IN THE DRILL PIPE DURING INSTALLATION FOR VARIOUS SEA STATE CONDITION

Significant Wave Height, Ft	Maximum RMS Bending Stresses In PSI For Various DP Length In FT					
	200	500	1000	5000	10000	20000
4	293	360	435	224	234	1319
8	520	750	757	513	613	2270
12	619	877	1329	994	873	2893
16	687	936	1910	1371	1088	3336

5.3.5 NATURAL FREQUENCIES AND PERIODS IN AXIAL OSCILLATION

Assume that there is no heave compensators. Then, the DP can be simulated like a heavy homogeneous string with a concentrated mass at the lower end. Natural frequencies are determined by means of formula (Reference 9)

$$\frac{\omega l}{a} \tan \frac{\omega l}{a} = \frac{M}{m}, \quad a = \sqrt{\frac{E}{\rho}},$$

where ω = natural frequency,

l = DP length,

a = sound velocity in material (steel),

ρ = mass density of material,

M = DP mass,

m = concentrated mass of the DP with BIP.

Relationship between the DP length and the fundamental natural frequency ω_1, and period T_1 is provided in FIG. 5.4. High tones of the axial oscillation have higher frequency and, consequently, less period.

5.3.6 DYNAMIC AXIAL STRESSES DUE TO SHIP HEAVE MOTION

Fig. 5.5 contains RAO of "GLOMAR CHALLENGER" in heave motion (Reference 8). As one can see by comparision, in the range below 3 SEC the heave response is

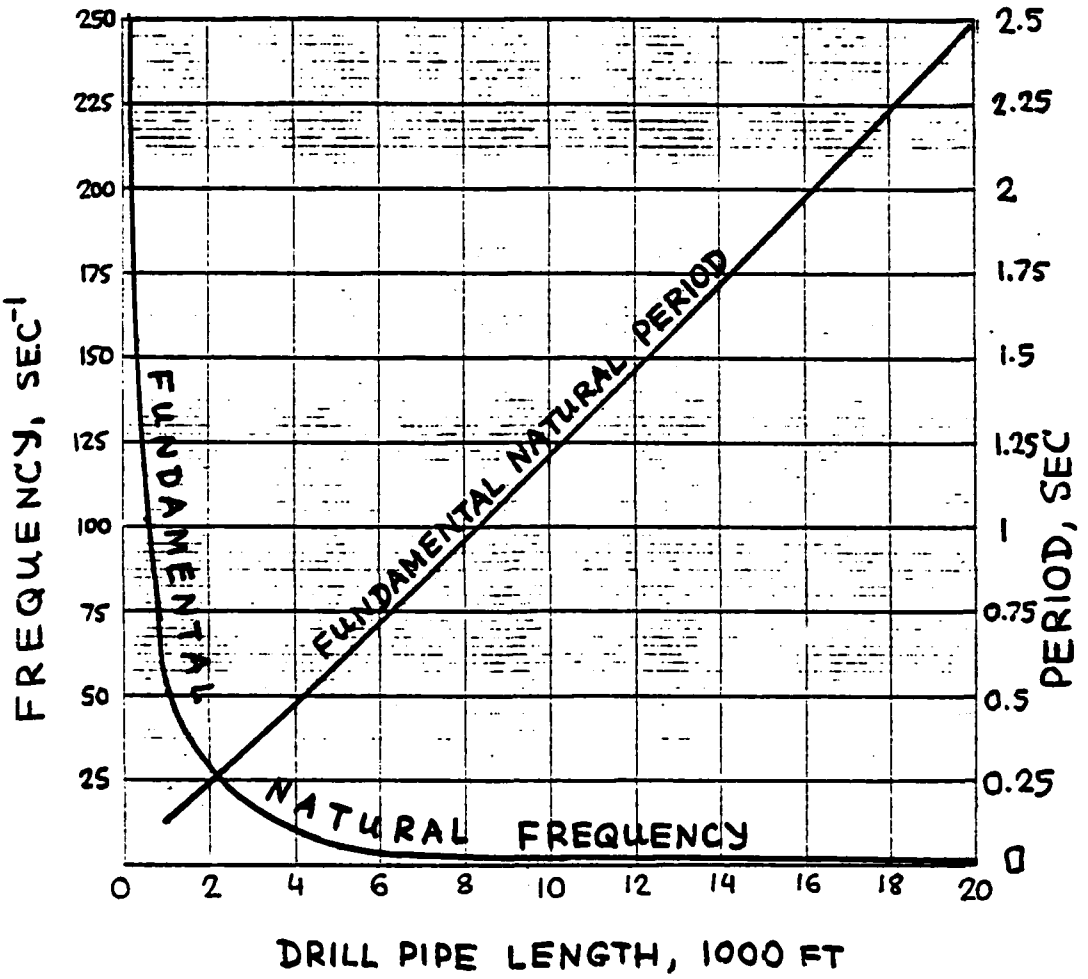


FIG. 5.4

FUNDAMENTAL NATURAL FREQUENCY AND PERIOD IN AXIAL OSCILLATION OF THE DRILL PIPE AS A FUNCTION OF THE INSTALLED LENGTH

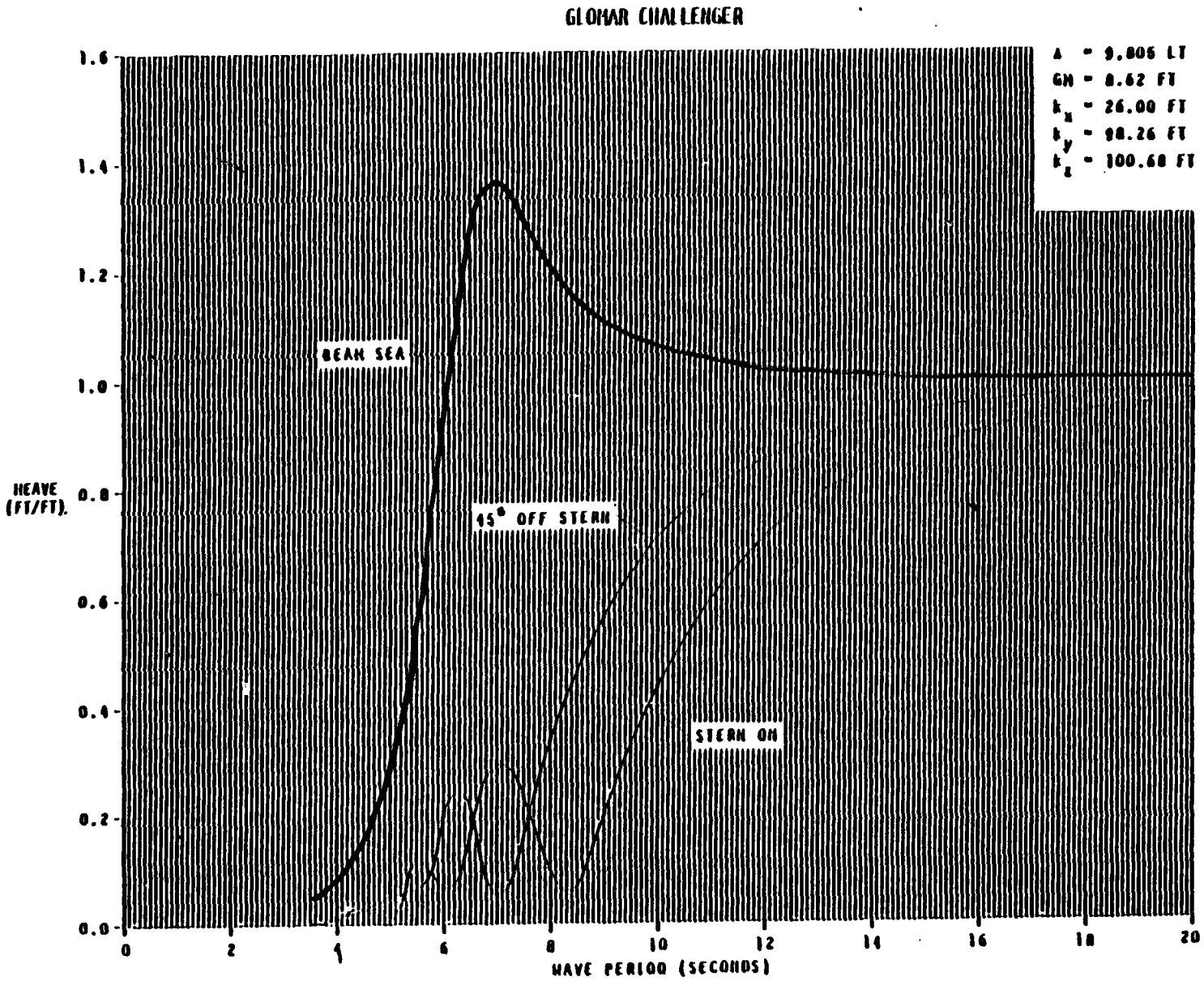


FIG. 5.5 RESPONSE AMPLITUDE OPERATOR OF "GLOMAR CHALLENGER" IN HEAVE MOTION

negligibly small. Heave natural period of the "GLOMAR CHALLENGER" is larger than 4 sec, and maximum value of it corresponds to 7 sec. Time duration of the heave loading is significantly more than the fundamental natural period and therefore its excitation does not generate any significant dynamic effect and additional stresses in the drill pipe. Consequently, it is concluded that the ship sway motion is the only significant source of dynamic stresses in the drill pipe.

5.3.7 TOTAL STRESSES

Total stresses are combined stresses due to current, own weight and RMS statistical values occuring for 4,8,12, or 16 ft significant wave height. Significant and maximum stresses are determined as follows:

Significant stress is equal to the stress due to dead weight and current summarized with double RMS maximum bending stress value;

Maximum stress is a sum of the stress due to dead weight and current and 3.72 times of RMS maximum bending stress value. Final results are presented in Tables 5.10 through 5.12.

Table 5.13 presents comparison of dynamic RMS component of deflection and bending stress with

appropriate static components. Results show that contribution of dynamic component decreases when the deployed length of the DP is getting larger.
For comparison purposes the last column of Tables 5.10 through 5.12 contains numerical information about bending stresses in the DP for the case when the lower end of it is located in the borehole. This information was prepared according to formula and graphs of "Parametric Analysis of Marine Risers for Deep Water Drilling" (Reference 3). Configuration of the DP corresponding to this case is conditionally called here as "installed pipe".

TABLE 5.10 COMBINED RMS BENDING STRESSES IN THE DRILL PIPE FOR VARIOUS SEA STATE CONDITIONS AND DP LENGTH

Significant Wave Height Ft	Combined Stresses In PSI for the DP Length in Ft						
	200	500	1000	5000	10000	20000	Installed Pipe
4	931	3036	4373	22712	30973	55352	53631
8	1158	3426	4695	23001	31352	56303	53632
12	1257	3553	5267	23482	31612	56926	53632
16	1325	3612	5848	23859	31827	57369	53635

TABLE 5.11 COMBINED SIGNIFICANT BENDING STRESSES FOR VARIOUS SEA STATE CONDITIONS AND DP LENGTH

Significant Wave Height, Ft	Significant Bending Stresses in PSI for the DP Length in Ft						
	200	500	1000	5000	10000	20000	Installed Pipe
4	1224	3396	4808	22936	31206	56670	53631
8	1678	4176	5451	23514	31965	58572	53633
12	1875	4430	6595	24476	32486	59818	53634
16	2011	4548	7757	25230	32915	60704	53635

TABLE 5.12 COMBINED MAXIMUM BENDING STRESSES FOR VARIOUS SEA STATE CONDITIONS AND DP LENGTH

Significant Wave Height, Ft	Combined Maximum Bending Stresses in Psi for the DP Length in Ft						
	200	500	1000	5000	10000	20000	Installed Pipe
4	1726	4014	5554	23321	31607	58934	54551
8	2571	5463	6751	24396	33018	62469	56460
12	2937	5936	8876	26183	33985	64784	58329
16	3190	6156	11036	27584	34782	66431	60138

TABLE 5.13 RMS COMPARISON OF DYNAMIC DEFLECTION AND BENDING STRESS WITH APPROPRIATE STATIC COMPONENTS

Drill pipe Length, Ft	Percent of dynamic RMS with respect to static component	
	Deflection	Bending Stress
200	13.5	92.3
500	11.4	35.0
1000	7.7	48.5
5000	2.8	6.1
10000	1.6	3.5
20000	6.8	6.2

According to Reference 10, the yield limit for DP steel corresponds to $\sigma_y = 135000$ psi. Reference 11 recommends to establish the allowable stresses for compact elements subjected to tension and bending as follows:

$$[\sigma] = 0.66\,\sigma_y = 89100 \text{ psi}.$$

Table 5.12 shows that even in most severe case of loading (maximum dynamic plus static) combined stresses do not exceed 66431 psi. Consequently, the drill pipe satisfies the strength condition for any sea state within 16 ft. significant wave height.

5.4 CONCLUSIONS & RECOMMENDATIONS

Details of this analysis are summarized in Section 4.0 "Summary of Results". The main results of this investigation are:

- The drill pipe behaves like a heavy homogeneous string. It means that the main contribution in its resistance belongs to the tension, and the bending stiffness can be neglected when the DP length is more than 300 ft.
- Dynamic behavior of the DP is determined for more severe case corresponding to ship sway motion for beam seas.

- Contribution of dynamic component of the deflection and bending stress decreases when the DP length gets longer.
- In case of no heave compensator ship heave motion does not cause additional dynamic stresses in the pipe.
- Installation can be performed for any sea state condition within 16 ft. significant wave height. The drill pipe strength will be assured for any random sea with characteristics which satisfy this limit.

It is recommended that the results obtained in this study are compared to the existing data and their results which can be obtained by using other similar methods, such as those of the DSDP, in the future.

6.0 REFERENCES

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10. "GLOMAR CHALLENGER" characteristics, Global Marine Inc.

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APPENDIX A

"NSSOS" COMPUTER PROGRAM

THEORETICAL BASIC FORMULATION

A MARINE SEISMIC SYSTEM OSCILLATION (MSSOS)

A.1 CALCULATION MODEL

Calculation model considers the DP as a heavy string with variable tension in it. The RS and BIP are simulated as a concentrated mass at the lower end of the DP. This calculation model was implemented in Reference 12.

A.2 COORDINATE SYSTEM

Coordinate system is shown in FIG. A.1.

A.3 ASSUMPTIONS

Following assumptions are considered:

- DP is homogeneous string,
- Tension can be described by linear relationship,
- The only exciting force is the ship motion due to wave action,
- Damping effect is neglected*

A.4 DIFFERENTIAL EQUATION

Differential equation is accepted in the form

$$-\frac{\partial}{\partial x}\left[T(x)\,y'(x,t)\right] + m\ddot{y}(x,t) = 0, \quad 0 \le x \le \ell, \; t > -\infty, \qquad (A.1)$$

* The procedure of handling damping effect is considered separately in Appendix B.

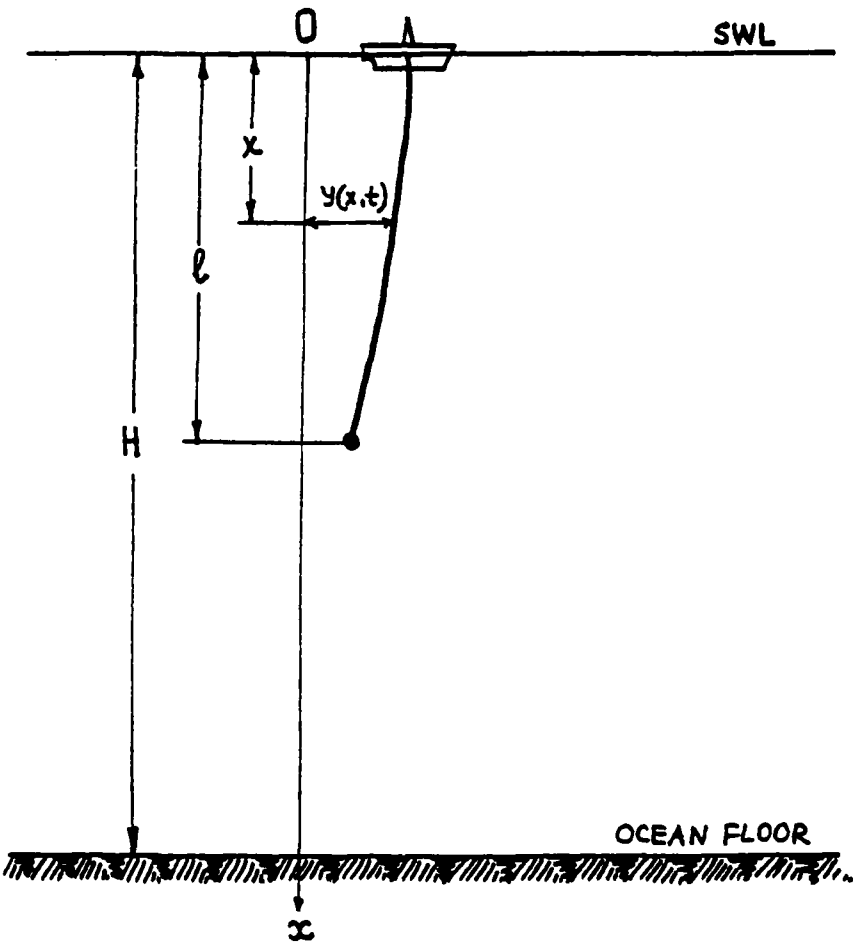


FIG. A.1

CALCULATION SCHEME AND COORDINATE SYSTEM

where m = DP mass per unit length including added masses,

$y(x,t)$ = lateral displacement of any arbitrary point of the DP,

$T(x)$ = variable tension in the DP equal to the wet weight of the DP located below the cross-section being considered.

This tension can be expressed by means of equation

$$T(x) = T_0 - \frac{x}{\ell}(T_0 - T_1), \quad 0 \leq x \leq \ell, \tag{A.2}$$

where T_0 denotes tension at the top, T_1 is tension at the bottom equal to the RS and BIP wet weight, ℓ is the deployed length of the DP.

A.5 BOUNDARY CONDITIONS

Boundary conditions correspond to the upper end subjected to kinematic excitation due to ship motion, the lower end-free with a concentrated mass at it, i.e.

$$y(0,t) = Se^{i\omega t}, \quad T_1 \cdot y'(\ell,t) = -M\ddot{y}(\ell,t), \quad t \to -\infty, \tag{A.3}$$

where S = ship complex amplitude in surge or sway motion,

ω = ship frequency in this motion,

M = concentrated mass at the lower end of the DP (RS and BIP),

i = imaginary unit.

A.6 EQUATION FOR REGULAR SHIP MOTION

This motion can be presented by relation

$$y(x,t) = y(x)e^{i\omega t}, \tag{A.4}$$

where $y(x)$ is the complex amplitude of forced oscillation.

Equation (A.1) and boundary conditions (A.3) can be written now in the form:

$$\frac{d}{dx}\left[T(x)y'(x)\right] + m\omega^2 y(x) = 0, \quad 0 \le x \le \ell, \tag{A.5}$$

$$y(0) = S, \quad y'(\ell) - \frac{\omega^2}{g} y(\ell) = 0, \tag{A.6}$$

where g is gravitational acceleration.

A.7 SOLUTION OF EQUATION (A.5)

Introduce new abscissa

$$z = 2\omega\sqrt{\frac{\ell}{g}\left(1+\mu-\frac{x}{\ell}\right)}, \quad 0 \le x \le \ell, \tag{A.7}$$

where μ is ratio between the wet weight of the RS with BIP and the rest of the DP. Then differential equation (A.5) may be presented in form of Bessel differentail equation (Reference 5)

$$\frac{d^2y(z)}{dz^2} + \frac{1}{z}\frac{dy(z)}{dz} + y(z) = 0, \quad z_1 \le z \le z_0, \tag{A.8}$$

$$z_1 = 2\omega\sqrt{\frac{\ell}{g}\mu}, \quad z_0 = 2\omega\sqrt{\frac{\ell}{g}(1+\mu)} \tag{A.9}$$

with solution

$$y(z) = A J_0(z) + B Y_0(z), \qquad z_1 \le z \le z_0, \tag{A.10}$$

where $J_0(z)$ and $Y_0(z)$ denote Bessel functions of the first and second kind, respectively, of zero order, A and B are arbitary constants. They can be obtained from boundary conditions (A.6) rewritten in terms of new independent variable z

$$y(z_0) = S$$

$$\left.\frac{dz}{dx}\right|_{x=\ell} \cdot y'(z) - \frac{\omega^2}{g} y(z_1) = 0,$$

where prime denotes integration with respect to z . Arbitrary constants can be found from a set of equations written in matrix form:

$$\begin{bmatrix} J_0(z_0) & Y_0(z_0) \\ J_1(z_1)+\frac{z_1}{2}J_0(z_1) & Y_1(z_1)+\frac{z_1}{2}Y_0(z_1) \end{bmatrix} \begin{bmatrix} A \\ B \end{bmatrix} = \begin{bmatrix} S \\ 0 \end{bmatrix}$$

To obtain this set, differentiation formulas for Bessel functions were used (Reference 5).

A.8 SLOPE OF THE DRILL PIPE

Slope of the DP can be obtained by differentiation of the general solution (A.10) with respect to x

$$y'(x) = -\frac{2\omega^2}{g z}\left[A J_1(z) + B Y_1(z)\right], \quad z_1 \le z \le z_0 \tag{A.11}$$

A.9 BENDING MOMENT

As well known, bending moment is proportional to the curvature of the pipe, i.e.

$$M(x) = -EI\,y''(x) = -\frac{4EI\omega^4}{g^2 z^2}\left\{A\left[-\frac{1}{z}J_1(z) + J_0(z)\right] + B\left[-\frac{1}{z}Y_1(z) + Y_0(z)\right]\right\}, \quad z_1 \le z \le z_0. \tag{A.12}$$

Here $J_1(z)$ and $Y_1(z)$ denote Bessel functions of the first order.

A.10 RAO FACTORS

RAO of deflections, slope and bending moment are defined by means of relations (A.10), (A.11) and (A.12) if one substitutes $S = 1$.

A.11 BENDING STRESS MAGNITUDE

Bending stress composes from two components:
σ_{ST} due to current and dead weight of the DP and
σ_{dyN} due to ship excitation, i.e.

$$\sigma = \sigma_{ST} + \sigma_{dyN} ,$$

with

$$\sigma_{ST} = \frac{T(x)}{F}, \quad \sigma_{dyN} = \frac{|M(x)|\,R}{I} , \tag{A.13}$$

where F = cross-sectional area,

R = outside diameter,

I = cross-sectional moment of inertia with respect to central axis.

RAO of dynamic component can be calculated if one writes $S=1$ in relation (A.13).

APPENDIX B

DAMPING EFFECT

B. DAMPING EFFECT

B.1 FORMULATION OF THE PROBLEM

Solution of the dynamic part of the DP behavior did not include damping effect due to water. To evaluate this effect which significantly reduces magnitudes of deflection, slope and bending moments for frequencies close to natural, the procedure described below was incorporated in "MSSOS" computer program.

B.2 DIFFERENTIAL EQUATION WITH DAMPING EFFECT

This equation can be written in form

$$-\frac{\partial}{\partial x}\left[T(x)\,y'(x,t)\right]+m\ddot{y}(x,t)=-C_L\,\dot{y}(x,t), \tag{B.1}$$

where C_L is linear damping coefficient. It can be expressed according to Reference 6, as follows

$$C_L=\frac{8}{3\pi}\,\omega\,|y(x)|\cdot\frac{1}{2}\rho d C_D, \tag{B.2}$$

where ρ = water mass density,

ω = circular frequency,

C_D = drag coefficient,

d = DP outside hydrodynamic diameter.

Boundary conditions are considered in form (A.3).

B.3 SOLUTION FOR CASE OF REASONANCE

Let

$$y(x,t) = y(x)e^{i\omega t},$$

then

$$\frac{d}{dx}\left[T(x)y'(x)\right] + m\omega^2 y(x) - i\omega C_L y(x) = 0, \tag{B.3}$$

$$y(0) = S, \quad y'(\ell) - \frac{\omega^2}{g} y(\ell) = 0. \tag{B.4}$$

Transform this problem with nonhomogeneous boundary conditions to a problem with zeroth boundary conditions. In this case

$$y(x) = Y(x) + C + Dx, \tag{B.5}$$

where $Y(x)$ is solution obtained in Appendix A, C and D are some arbitrary constants. Satisfying boundary conditions (B.4), one obtains

$$C = S, \quad D = -\beta \cdot \frac{S}{\ell}, \quad \beta = \frac{1}{1 - \frac{g}{\ell\omega^2}}. \tag{B.6}$$

Consequently,

$$y(x) = Y(x) + S\left(1 - \beta\frac{x}{\ell}\right). \tag{B.7}$$

Substitute (B.7) into (B.3) and take into consideration the fact that $Y(x)$ satisfies equation (B.3) without the third item, then

$$Y(x) = \frac{S}{\omega C_L} \cdot F(x) e^{i\varphi}, \tag{B.8}$$

with

$$F(x) = \sqrt{\left[\omega C_L \left(1 - \frac{\beta}{\ell} x\right)\right]^2 + \left[m\omega^2 \left(1 - \frac{\beta}{\ell} x\right) - \frac{\beta (T_0 - T_1)}{\ell^2}\right]^2}. \tag{B.9}$$

Here φ denotes some angle which indicates the phase relation between ship motion and DP response. Expression

$$Y_{MAX}(x) = \frac{S}{\omega C_L} F(x) \tag{B.10}$$

limits the magnitude of deflection along the DP for any frequency ω which is close to any natural frequency of the DP in lateral oscillation.
Similarly, the upper limits of the maximum slope and bending moment are found. Final results without insignificant details are provided below:

$$Y'_{MAX}(x) = \frac{S}{\omega C_L} F'(x), \tag{B.11}$$

$$M_{MAX}(x) = EI \left| Y''(x) \right| = \frac{SEI}{\omega C_L} \left| F''(x) \right|. \tag{B.12}$$

As it was mentioned earlier, for RAO factors one has to substitute $S=1$ in relations (B.8), (B.11) and (B.12).

APPENDIX G

PHASE IV-CONFIGURATION I
MOBILIZATION AND DEPLOYMENT ESTIMATE

25 September 1980

PHASE IV - CONFIGURATION I MOBILIZATION AND DEPLOYMENT ESTIMATE

October 1981 - September 1982

G-1 TASK SUMMARIES

TASK 1 - CONFIGURATION I DEPLOYMENT EQUIPMENT PROCUREMENT

- Procure majority of all MSS deployment equipment.
- Provide for QC and inspection services at vendor plants.
- Covers engineering support to procurement items.

TASK 2 - CONFIGURATION II HARDWARE ASSEMBLY AND CHECKOUT

- Ship specialized hardware to Japan.
- Set up field office in Japan (2 months).
- Receive and inspect equipment.
- Assemble equipment and checkout operation, fit clearances, etc.

TASK 3 - CONFIGURATION I OPERATIONAL PROCEDURES

- Finalize operational procedures in conjunction with DSDP and operational crew.
- Conduct final design and safety reviews on deployment.

TASK 4 - CONFIGURATION I MOBILIZATION

- Four day shipyard mobilization (Japan).
- Transfer equipment from field office to ship.
- Install hardware on vessel.
- Assembly of test personnel.
- Logistic support.

TASK 5 - CONFIGURATION I DEPLOYMENT OPERATIONS

- 60 day leg - 4 men
- Transmit to site from Japan
- Deployment of MSS
- Return to U.S.
- Does not include CHALLENGER costs.

TASK 6 - CONFIGURATION I DEMOBILIZATION

- Removal of special equipment from vessel.
- Test personnel back to GMDI.

TASK 7 - CONFIGURATION I DEPLOYMENT REPORT

- Complete report of Configuration I activity.

TASK 8 - CONFIGURATION I INTEGRATION

- Coordinate all deployment activities.
- Maintain interface control drawings and specifications.
- Maintain updated activity schedule.
- Interface with DSDP.

TASK 9 - CONFIGURATION II DEPLOYMENT CONCEPT EVALUATION

- Define Configuration II deployment specifications.
- Perform trade-off study of fly-in-package configurations.
- Select alternate reentry design concept.

TASK 10 - FLY-IN-PACKAGE TEST DESIGN

- Define June 1982 Fly-In test configuration and objectives.
- Prepare design drawings and procurement specifications.

TASK 11 - CONFIGURATION II DESIGN

- Define June-July 1983 Fly-In platform configuration.
- Prepare design drawings and procurement specifications.

TASK 12 - PROGRAM MANAGEMENT

- Coordination with Gould, Scripps, NSF, NORDA
- Overall direction of deployment program.
- Progress Reports.
- Final Reports.
- Special Briefing.

TASK 13 - CONFIGURATION II MOBILIZATION PLANNING

- Define Port of Operations
- Prepare Mobilization Plan
- Prepare Fabrication and Assembly Plan
- Detailed Cost Estimate

25 September 1980

PHASE IV - CONFIGURATION I MOBILIZATION AND DEPLOYMENT

October 1981 - September 1982

G-2 COST ESTIMATES

TASK 1 - CONFIGURATION I EQUIPMENT PROCUREMENT

Dept 552 (QC Inspection)	3	
552	1	
541	3	
542	1	
	8 mm	
ODC:		
Travel	$ 20,000	
Shipment to S.F.	10,000	
Equipment Procurement Costs	428,500	(See G-3)
	$458,500	

TASK 2 - CONFIGURATION I HARDWARE ASSEMBLY AND CHECKOUT

Field Office Personnel	
2 men 552 - 2 months	4 mm
1 man 541 - 2 months	2 mm
Shipment of Spec. Hardware US to Japan - Fast Freight	85,000
Field Office (Japan) 2 months	$16,500
1 secretary - 2 months	6,000
Subsistence 3 men x 60 days at $150 including transportation	27,000
Workers Local 2 - 1 month	6,000
Pickup Truck - 2 months	3,000
Mobile Crane - 20 days	12,000
Port Generator (10 KW)	4,400
Storage Area (Shipyard)	6,000
Travel - 6 RT - Japan @$1200	7,200
Misc. Supplies	4,000
	$92,100

TASK 3 - CONFIGURATION I OPERATIONAL PROCEDURES

Engineering	540	2 mm
	541	2
	542	1
	543	1
		6 mm
Computer		4,000
Travel		
2 - 2 men NORDA		2,400
2 - 2 men TEXAS		2,000
Local		600
Miscellaneous		1,000
		10,000

TASK 4 - CONFIGURATION I FINAL MOBILIZATION

Port Eng. & Mat.	552	½ mm
Closeup Office 10 days		
6 x 4 days x 100		$ 2,400
Rental car (2)		300
Misc. phone/services		2,000
Logistic support		20,000
Travel Local		500
Travel U.S. - 2		2,400
Shipyard Installation		75,000
		$ 102,600

TASK 5 - CONFIGURATION I DEPLOYMENT OPERATIONS

4 men x 2 months	540	2 mm	
	541	4	
	552	2	
		8 mm	
Travel to Japan	4-10 days		$10,800
Travel to U.S.	4		4,000
Overtime Bonus			
$100/day x 4 x 60			24,000
Miscellaneous Support			4,000
			$42,800

TASK 6 - CONFIGURATION I DEMOBILIZATION

Port Engineer	552	2 mm	
Remove Equipment			$70,000
Flight Back to U.S.			1,200
Subsistence 10 days (Alaska)			2,000
Ship Equipment to U.S.			50,000
			$123,200

Task 7 - CONFIGURATION I DEPLOYMENT REPORT

Engineering	540	½ mm	
	541	2	
	545	1	
	575	1	
		4½ mm	
Report Publication			$2,000
Travel NORDA 2 - 2 days			2,500
Travel TEXAS 4 - 2 days			3,200
			$7,700

TASK 8 - CONFIGURATION I INTEGRATION

Engineering	540	½	
	541	1½	
	542	½	
	545	2	
	546	1	
	547	½	
		6 mm	
Travel	2 - 2 days	Mississippi	$2,400
	2 - 2 days	Washington, DC	3,000
	2 - 2 days	Texas	2,000
	Local		2,000
			$9,400

TASK 9 CONFIGURATION II DEPLOYMENT CONCEPT EVALUATION

Engineering	540	1	
	541	2	
	542	1	
	543	1	
	546	1½	
	547	½	
		7 mm	
Computer			$ 2,000
Travel	2 - 2 days	Local	500
	2 - 2 days	Washington, DC	2,400
	2 - 2 days	Hawaii	3,000
			$ 7,900

TASK 10 - FLY-IN-PACKAGE TEST DESIGN

Engineering	540	2
	541	8
	542	2
	543	4
	546	4
	547	2
		22 mm

Computer	$4,000
Travel - Local	1,000
Consultant	3,000
	$8,000

TASK 11 - CONFIGURATION II DEPLOYMENT DESIGN

Engineering	540	2
	541	10
	542	4
	543	4
	546	4
	547	2
	548	2
		28 mm

Consultant 50 days @ 300	$15,000
Travel 2 - 2 trip Washington, DC	3,000
2 - 2 trip Hawaii	3,000
2 - 2 trip Mississippi	2,400
Local	2,000
Computer	4,000
Sub-contract NCEL	8,000
	$37,400

TASK 12 - PROGRAM MANAGEMENT

Program Manager 100%	540	6 mm
Upper Management	565	3
Technical Review	540	2
Interface Control	545	3
Schedules	545	3
Report	575	2
Vu-graph/Art	575	2
		15 mm
Travel 4 - 2 man trips Washington		$6,000
2 - 2 man Japan		6,000
4 - 2 man NORDA		4,800
Local		2,000
Reports		2,000
Briefing Aid		1,000
Miscellaneous		5,000
		$26,800

TASK 13 - CONFIGURATION II MOBILIZATION PLANNING

	552	5 mm
	551	1 mm
ODC: Travel 4 Foreign Trips 8 Local Trips Miscellaneous		$25,000

25 September 1980

CONFIGURATION I HARDWARE PROCUREMENT ESTIMATE

G-3 PROCUREMENT ESTIMATE	ROM	REMARKS
BASELINE CONFIGURATION I DEPLOYMENT		
Reentry Sub (2)	$90,000	
BIP's (2)	--	Geotech
Reentry Tool	25,000	
EM Diesel Powered Cable Winch	--	Geotech
EM Cable	--	Gov't Supplied
A-Frame	--	At-Sea-Test
Reentry Tool Console (Refurbish)	60,000	
Reentry Tool EM Cable/Winch	45,000	
BIP Control Console	--	Geotech
Mooring Handling Equipment	4,000	
Subsurface Bucy Handling Equipment	5,000	
EM Cable Sheaves	--	At-Sea-Test
BIP Release Tool - New	1,500	
Drill Collar Sub	3,000	
Drill String, Bumper Subs, etc.	--	DSDP Supplied
Lowering Line	15,000	
Lowering Winch	--	Gov't Supplied
Reentry Cones (2)	130,000	
16 inch Casing (2)	17,000	
11-3/4 inch Casing (2)	28,800	
Aft A-Frame	58,300	
Anchor Handling Pendant - 20,000 feet	45,000	
Drill Bits (2 Holes)	50,000	
Casing Hangers (2)	60,000	
Cement (Slow Curing)	16,000	
Borehole Angle Measurement Inst. (Lease)	15,000	
Special 8½ inch Drill collar	10,700	
FLY-IN PACKAGE TEST		
Fly-In Package w/Thruster	65,000	
Acoustic Position Sensor Console - Rent	25,000	
Fly-In Package Reentry Beacon	15,000	
Associated Tools and Spare Parts	40,000	
Packaging	25,000	
Shipment/Handling	40,000	
	$889,300	

APPENDIX H

SPECIFICATIONS

H-1 Development Test Specification

H-2 Configuration I Reentry Preliminary Specification

APPENDIX H-1

DEVELOPMENT TEST SPECIFICATION

SPC-001-004

SPECIFICATION

FOR

MARINE SEISMIC SYSTEM

TEST PROGRAM

(USAGE & FUNCTION TEST)

W. BUCHANAN

JOB 00001 TASK 210300

8 SEPTEMBER 1980

PREPARED BY: W. Buchanan
W. BUCHANAN

APPROVED BY/DATE:

P R Rimington 12 Sept. 80
RESPONSIBLE ENGINEER

/
MGR. MECHANICAL ENGINEERING

/
PROJECT MANAGER

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2	DESCRIPTION OF TEST	2
3	INSTRUMENTATION OF TEST	5
4	TEST PARAMETERS	6
5	EXPECTED RESULTS	7
6	TABLES & SKETCHES	8

SECTION 1 - OBJECT OF TEST

This test is being conducted to prove that the BIP Reentry Tool Assembly will withstand the shock loads imposed upon it by 12 reentry attempts without deformation of the stinger. The test will verify that the BIP package can pass through the stinger without jamming or cable entanglement. It will demonstrate that the sonar reentry tool can be positioned correctly in the hydraulic plug/sonar adaptor and that the adaptor can be moved from the bottom of the stinger to the hydraulic plug position in the BIP carriage control sub. A temporary hydraulic system will be used to move the BIP carriage assembly from the storage position in the BIP carriage housing, to the BIP deployment position to prove that the transfer mechanism can survive the shock loads generated during the 12 reentry attempts.

The Hydraulic System will also be used to operate the mechanism for removing the cable retainer plate.

SECTION 2 - DESCRIPTION OF TESTS

2.1 Items Required

For this test program the actual BIP Reentry Tool Assembly will be used. This is made up of the BIP carriage control sub; the BIP carriage housing assembly; the BIP carriage assembly and the reentry sub stinger. A dummy BIP will be made with a cable attached having the same dimensions and weight as the original and will be installed in the BIP carriage assembly with the carriage assembly in the storage position of the BIP carriage housing.

The hydraulic plug/sonar adaptor will be installed in the sonar deployment position at the bottom end of the stinger. A dummy sonar reentry tool will be made having the same dimensions and weight as the original. The reentry cone will be simulated by the angled target plate shown on Sketch WB-8-11-80-2.

ITEM	QTY	DESCRIPTION	REMARKS
1	2	BIP CARRIAGE CONTROL SUB	
2	2	BIP CARRIAGE HOUSING ASSEMBLY	
3	2	BIP CARRIAGE ASSEMBLY	
4	2	REENTRY SUB STINGER	
5	2	HYDRAULIC PLUG/SONAR ADAPTOR	
6	1	DUMMY BIP WITH 1-1/4" DIA CABLE ATTACHED	
7	1	DUMMY SONAR REENTRY TOOL	
8	2	BAKER RKH BY-PASS BLANKING PLUG 4"	BAKER COMMODITY NO. 806-91-4000
9	2	BAKER MI PROBE	BAKER COMMODITY NO. 812-14-4000
10	2	OTIS RUNNING & PULLING TOOL	OTIS 40GS 37

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2.2 Order of Tests

2.2.1 Sonar

With everything assembled and the dummy BIP in the storage position and the hydraulic plug/sonar adaptor lodged in the bottom of the stinger, a deployment test of the dummy sonar reentry tool will be conducted. This will entail lowering the Dummy Sonar Reentry Tool (DSRT) by its cable down through the BIP carriage control sub; the BIP housing assembly; the BIP reentry sub stinger and insuring that the DSRT lodges firmly in the hydraulic plug/sonar adaptor. This test will also be conducted after every reentry attempt to insure that the sonar adaptor or reentry tool are not damaged.

After the reentry tests, the dummy sonar reentry tool will be removed and the Baker by-pass blanking plug & probe will be lowered on a line with an Otis running & pulling tool to engage with the hydraulic plug/sonar adaptor,(HP/SA). The line will be reeled in until the HP/SA is moved up into the BIP carriage control sub where the retaining ring on the HP/SA will engage with a slot.

2.2.2 Impact Test

An impact test will be conducted with all the test equipment assembled in the BIP reentry tool. With the sonar tool removed and the HP/SA positioned in the lower tip of the stinger either one of two methods (Items 1 and 2 below), may be used for conducting the axial impact test. The swing test to be used is described in Item 3.

1) The first axial method is a free fall test where the impact velocity will be generated by the free fall height. The number of test repetitions, velocities and related heights as listed in Table 1.b.

2) The second axial method is a controlled lowering by a drawworks giving a measured uniform velocity at impact. The number of tests and the controlled uniform velocities are shown under test parameters. See Section

3) The swing impact test will use simple pedulum motion to insure that the velocity of impact is as specified in the test requirement list. For swing distances and swing impact velocities see Table 1.a.

2.2.3 BIP Transfer

When the HP/SA is in the BIP carriage control sub it acts as a seal for directing high pressure fluid to the BIP hydraulic system. Hydraulic fluid at 2500 psi is used to actuate the hydraulic cylinders which will transfer the BIP carriage assembly from the storage position to the deployment position where the BIP will fall out of the BIP carriage assembly, down the reentry sub stinger on its way into the hole. This test will verify that the transfer mechanism is working and that the deployment of the BIP can be achieved.

2.2.4 Cable Retainer Plate Removal

By increasing the fluid pressure to 3000 psi, a rupture disk fails and permits the pressure fluid to actuate the cable retaining cylinder. This causes the retaining plate to drop out and permits the passage of the BIP cable through the reentry sub stinger slot. Careful observations will be made to make sure the plate removal takes place and that the 1/4" cable can pass down the slot without kinking or damage.

SECTION 3 INSTRUMENTATION OF TESTS

The following area of the system will be instrumented:

1) The bottom end of the reentry sub stinger for recording the impact loads during the drop tests, the swing impact test and the "G" loading.

2) The top end of the reentry sub stinger will be instrumented to record strain and bending loads at this point during the drop tests and the swing impact tests.

3) The dummy BIP will be instrumented about its center of gravity when lodged in the BIP carriage assembly and in the storage position to record the axial, lateral and "G" loads imposed on the BIP during drop tests and swing impact tests. (See also Sketch WB-8-11-80-3).

4) A high speed movie camera will be used to record the tests and to establish the impact-time relationships.

SECTION 4 TEST PARAMETERS

4.0 Weights & Dimensions

1)	Bip Reentry Tool Assembly, approx.	=	16,000 Lbs.
2)	Dummy BIP	=	3,300 Lbs.
3)	Dummy Sonar	=	225 Lbs.
4)	HA/SA	=	440 Lbs.
	Total Dry Weight of One Complete		19,965 Lbs.
	Test Unit. Approx.	=	20,000 Lbs.
5)	BIP Reentry Tool Assy. Total Length	=	68 Ft. approx.
	See also Dwg. E001-		
6)	Dummy BIP Total Length	=	28 ft. 6 in.
	See also Sketch WB-9-9-80-2		
7)	Dummy Sonar Reentry Tool Total Length	=	12 Ft. Approx.
	See also Sketch WB-9-9-80-1		
8)	HP/SA Total Length	=	3 ft 6 In.
	See also Dwg.		

9)	Free Fall Velocities	2 FPS
	For Drop Test and	4 FPS
	Controlled	8 FPS
	Lowering Velocities	10 FPS
10)	Swing Test Velocities	1 FPS
		2 FPS
		4 FPS

Horizontal distances for the swing impact velocities are shown on Table 1.a Section 6.0

Vertical fall distances for various impact velocities are shown on Table 1.b Section 6.0

SECTION 5 EXPECTED RESULTS

1) The impact and "G" loading at the bottom end of the reentry sub stinger both in an axial and lateral direction.

2) The strain and moment forces at the top end of the reentry sub stinger where the stinger joints the BIP carriage housing assembly.

3) The impact and "G" loading in the dummy BIP both in an axial and lateral direction.

4) In the remainder of the system it should be sufficient to demonstrate that all systems operate acceptably during a function test.

5) Other tests may be required at the time of testing at the discretion of GMDI if there are indications that this information would be invaluable for future designs and can be gathered at little additional cost or effort.

SECTION 6 TABLES

TABLE 1a
SWING IMPACT TEST

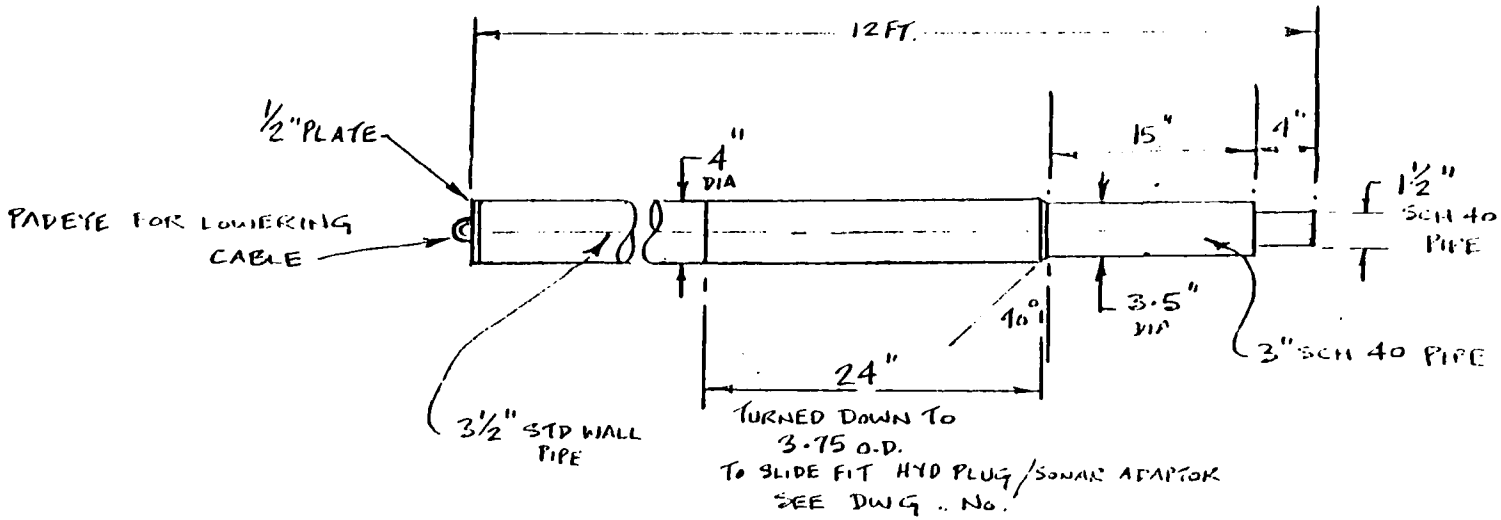
STINGER LENGTH(FT)	SWING IMPACT VELOCITY FT/SEC	x = HORIZONTAL DISTANCE FROM TARGET (FT)
90	1	1.313
80	1	1.237
70	1	1.157
60	1	1.071
50	1	0.975
90	2	2.625
80	2	2.475
70	2	2.315
60	2	2.142
50	2	1.92
90	4	5.25
80	4	4.95
70	4	4.63
60	4	4.284
50	4	3.84

TABLE 1b
FREE-FALL IMPACT TEST

IMPACT VELOCITY (FPS)	DROP HEIGHT (INS)
2	0.75
4	2.98
6	6.70
8	11.92
10	18.63

MATERIAL — STEEL

TOTAL WEIGHT SHOULD BE 225 LBS



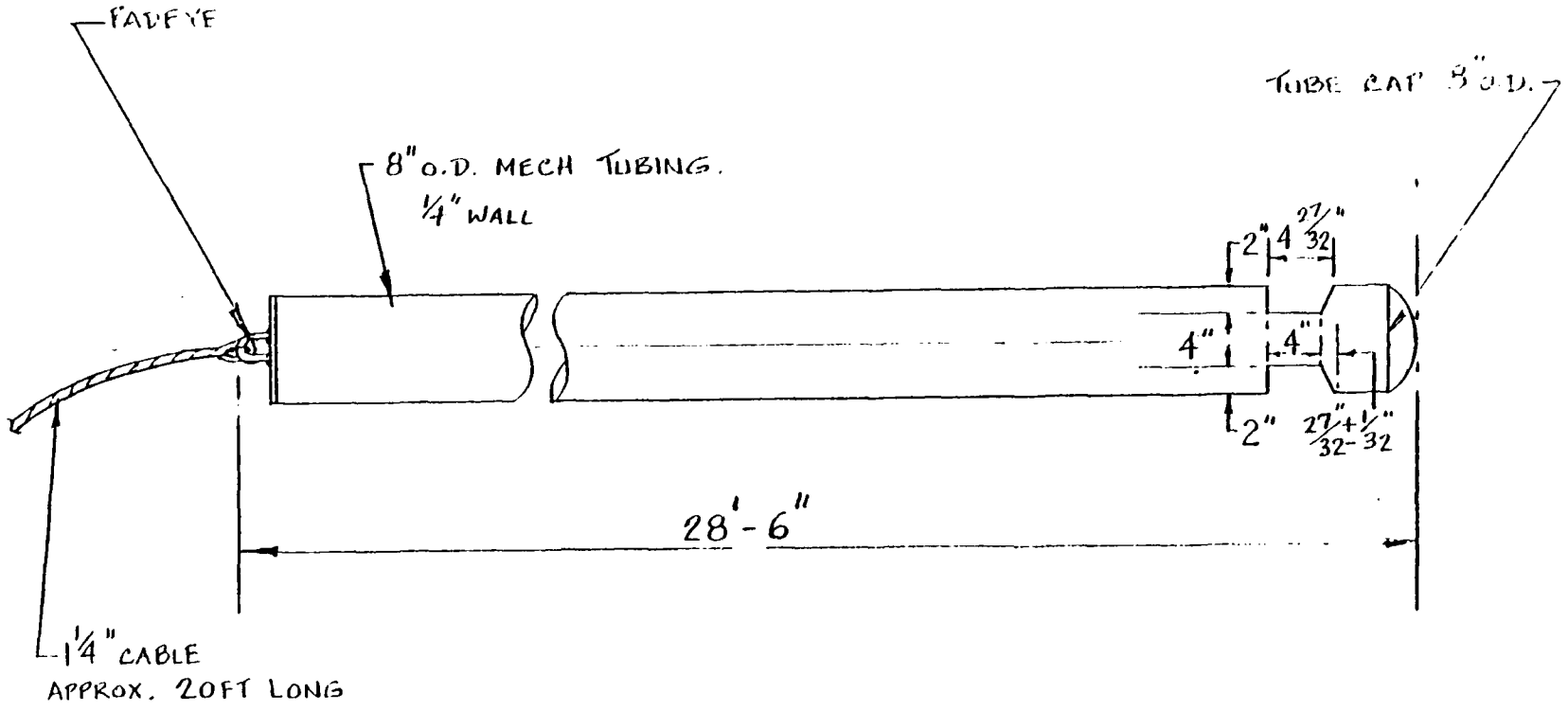
DETAIL

DUMMY SONAR RE-ENTRY TOOL

SKETCH. No W.B-9-9-80-1.

61-H W. BUCHANAN 9 SEPT. 1980

MATERIAL — STEEL
EST. TOTAL WEIGHT — 3300 LBS.



DETAIL

DUMMY BIP PACKAGE

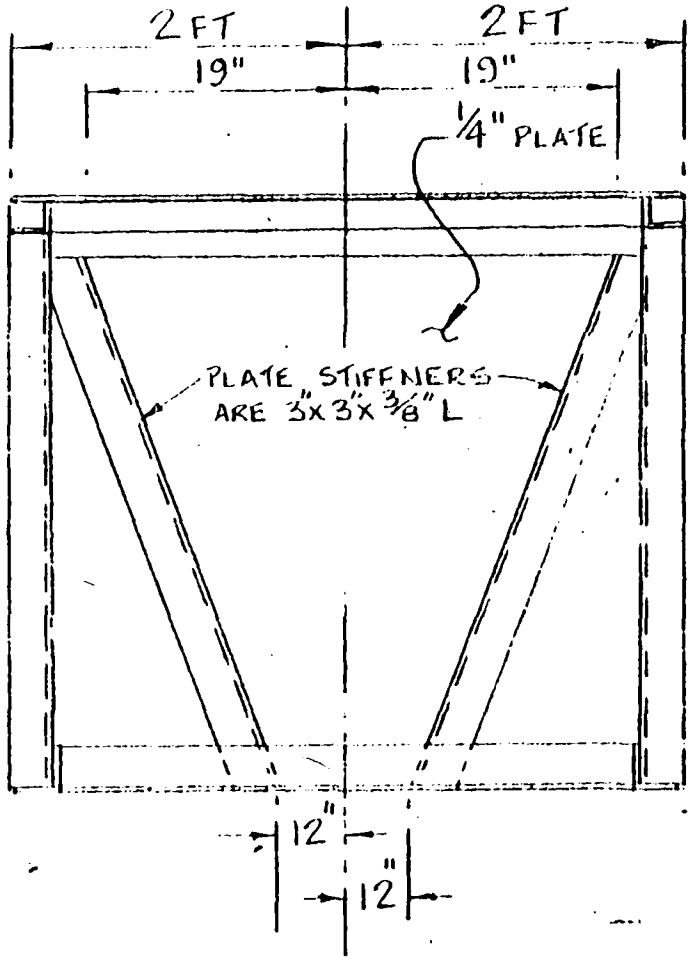
SKETCH. No. WB-9-9-80-2

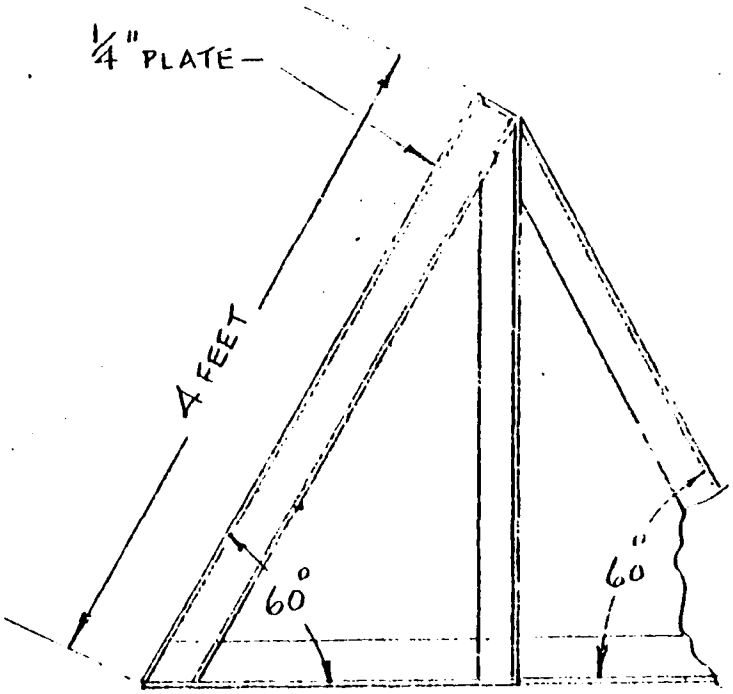
Job 0001 Task 2.1.00

TARGET FOR IMPACT TEST

MATERIAL - STEEL
ALL OTHER DIMENSIONS TO FABRICATORS DISCRESSION

TARGET TO BE ANCHORED AT TEST SITE TO SUIT EXISTING CONDITIONS

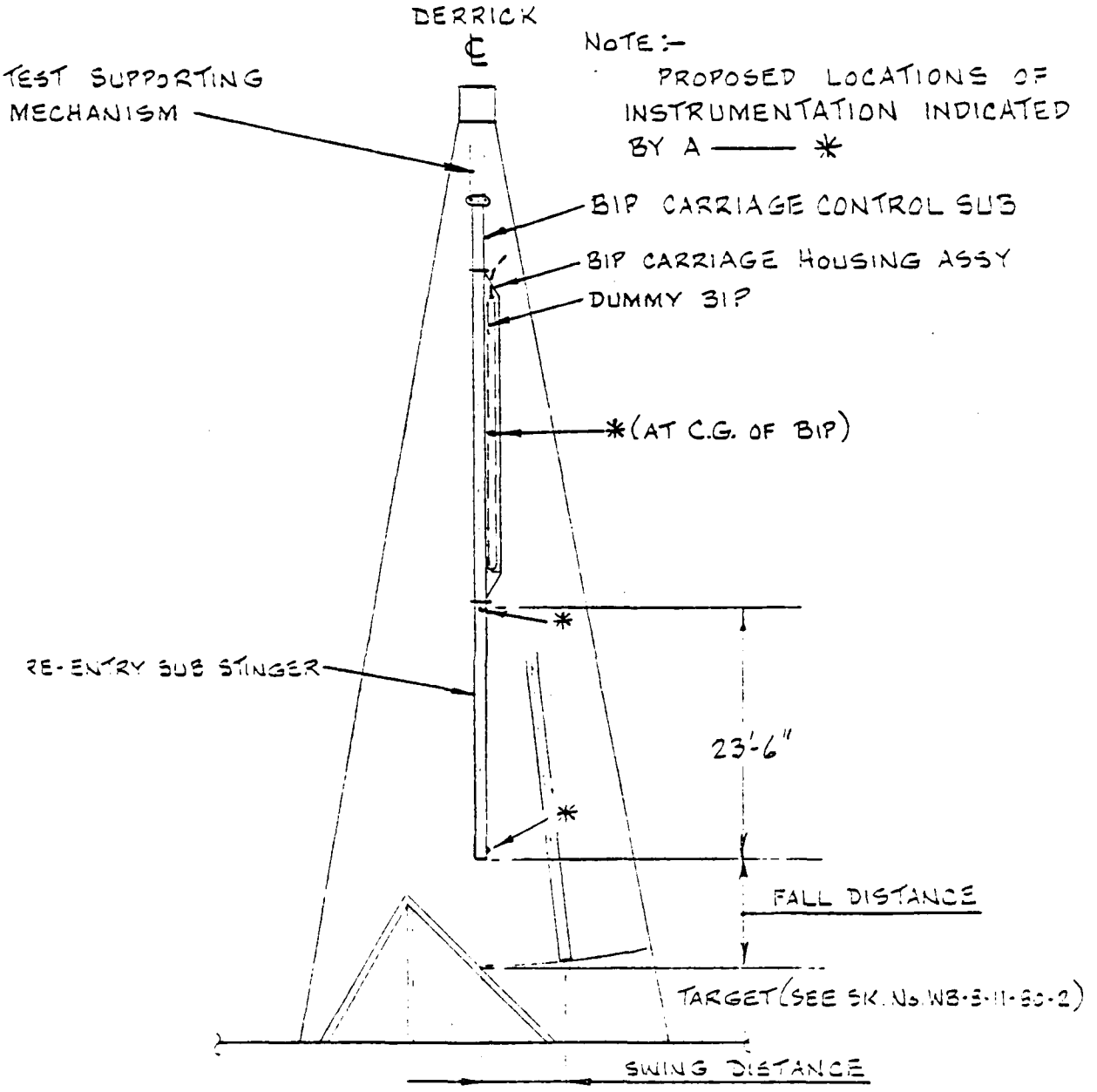




SKETCH. No. WB-8-11-80-2

W.B 8-11-80

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MARINE SEISMIC SYSTEM (M.E.S.

TEST SET-UP

SKETCH No. WB-3-11-60-3.

APPENDIX H-2

PRELIMINARY SPECIFICATION
FOR MARINE SEISMIC SYSTEM
CONFIGURATION I REENTRY SUB

SECTION 1 - OBJECT OF TEST

This test is being conducted to prove that the Configuration I BIP Reentry Tool Assembly will withstand the shock loads imposed upon it by 12 reentry attempts without deformation of the stinger. The test will verify that the BIP package can pass through the stinger without jamming or cable entanglement. It will demonstrate that the sonar reentry tool can be positioned correctly in the hydraulic plug/sonar adaptor and that the adaptor can be moved from the bottom of the stinger to the hydraulic plug position in the BIP carriage control sub. A temporary hydraulic system will be used to move the BIP carriage assembly from the storage position in the BIP carriage housing, to the BIP deployment position to prove that the transfer mechanism can survive the shock loads generated during the 12 reentry attempts.

The Hydraulic System will also be used to operate the mechanism for removing the cable retainer plate.

SECTION 2 - DESCRIPTION OF TESTS

2.1 ITEMS REQUIRED

For this test program the Configuration I BIP Reentry Tool Assembly will be used. This is made up of the BIP carriage control sub; the BIP carriage housing assembly; the BIP carriage assembly and the reentry sub stinger. A dummy Configuration I BIP will be made with a cable attached having the same dimensions and weight as the original and will be installed in the BIP carriage assembly with the carriage assembly in the storage position of the BIP carriage housing.

The hydraulic plug/sonar adaptor will be installed in the sonar deployment position at the bottom end of the stinger. A dummy sonar reentry tool will be made having the same dimensions and weight as the original. The reentry cone will be simulated.

2.2 ORDER OF TESTS

2.2.1 Sonar

With everything assembled and the dummy BIP in the storage position and the hydraulic plug/sonar adaptor lodged in the bottom of the stinger, a deployment test of the dummy

sonar reentry tool will be conducted. This will entail lowering the Dummy Sonar Reentry Tool (DSRT) by its cable down through the BIP carriage control sub, through the BIP housing assembly and the BIP reentry sub stinger, and insuring that the DSRT lodges firmly in the hydraulic plug/sonar adapter. This test will also be conducted after every attempt to insure that the sonar adapter or reentry tool are not damaged.

After the reentry tests, the dummy sonar reentry tool will be removed and the Baker by-pass blanking plug and probe will be lowered on a line with an Otis running and pulling tool to engage with the hydraulic plug/sonar adaptor, (HP/SA). The line will be reeled in until the HP/SA is moved up into the BIP carriage control sub where the retaining ring on the HP/SA will engage with a slot.

2.2.2 Impact Test

An impact test will be conducted with all the test equipment assembled in the BIP reentry tool. With the sonar tool removed and the HP/SA positioned in the lower tip of the stinger either one of two methods (Items 1 and 2 below), may be used for conducting the axial impact test. The swing test to be used is described in Item 3.

1) The first axial method is a free fall test where the impact velocity will be generated by the free fall

height. The number of test repetitions, are listed in Section 4.

2) The second axial method is a controlled lowering by a drawworks giving a measured uniform velocity at impact. The number of tests and the controlled uniform velocities are shown under test parameters. See Section 4.

3) The swing impact test will use simple pendulum motion to insure that the velocity of impact is as specified in the rest requirement list.

2.2.3 BIP Transfer

When the HP/SA is in the BIP carriage control sub it acts as a seal for directing high pressure fluid to the BIP hydraulic system. Hydraulic fluid at 2500 psi is used to actuate the hydraulic cylinders which will transfer the BIP carriage assembly from the storage position to the deployment position where the BIP will fall out of the BIP carriage assembly, down the reentry sub stinger on its way into the hole. This test will verify that the transfer mechanism is working and that the deployment of the BIP can be achieved.

2.2.4 Cable Retainer Plate Removal

By increasing the fluid pressure to 3000 psi, a rupture disk fails and permits the pressure fluid to actuate the

cable retaining cylinder. This causes the retaining plate to drop out and permits the passage of the BIP cable through the reentry sub stinger slot. Careful observations will be made to make sure the plate removal takes place and that the .69" cable can pass down the slot without kinking or damage.

SECTION 3 - INSTRUMENTATION OF TESTS

The following areas of the system will be instrumented:

1) The bottom end of the reentry sub stinger for recording the impact loads during the drop tests, the swing impact test and the "G" loading.

2) The top end of the reentry sub stinger will be instrumented to record strain and bending loads at this point during the drop tests and the swing impact tests.

3) The dummy BIP will be instrumented about its center of gravity when lodged in the BIP carriage assembly and in the storage position to record the axial, lateral and "G" loads imposed on the BIP during drop tests and swing impact tests.

4) A high speed movie camera will be used to record the tests and to establish the impact-time relationships.

SECTION 4 - TEST PARAMETERS

4.1 WEIGHTS & DIMENSIONS

1)	BIP Reentry Tool Assembly, approx.		= 16,000 Lbs.
2)	Dummy BIP		= 3,300 Lbs.
3)	Dummy Sonar		= 225 Lbs.
4)	HA/SA		= 440 Lbs.
	Total Dry Weight of One Complete		19,965 Lbs.
	Test Unit. Approx.		= 20,000
5)	BIP Reentry Tool Assembly Total Length		= 68 Ft. Approx.
6)	Dummy BIP Total Length		= 28 Ft. 6 In.
7)	Dummy Sonar Reentry Tool Total Length		= 12 Ft. Approx.
8)	HP/SA Total Length		= 3 Ft. 6 In.
9)	Free Fall Velocities	2 FPS	
	For Drop Test and	4 FPS	
	Controlled	8 FPS	
	Lowering Velocities	10 FPS	
10)	Swing Test Velocities	1 FPS	
		2 FPS	
		4 FPS	

SECTION 5 - TEST RESULTS DESIRED

1) The impact and "G" loading at the bottom end of the reenty sub stinger both in an axial and lateral direction.
2) The strain and moment forces at the top end of the reentry sub stinger where the stinger joins the BIP carriage housing assembly.
3) The impact and "G" loading in the dummy BIP both in axial and lateral direction.
4) In the reamainder of the system it should be sufficient to demonstrate that all systems operate acceptably during a function test.
5) Other tests may be required at the time of testing at the discretion of GMDI if there are indications that this information would be invaluable for future designs and can be gathered at little additional cost or effort.

APPENDIX I

CABLE DATA

I-1 Cable Entanglement Evaluation

I-2 Cable Tensioning Factors

APPENDIX I-1

CABLE ENTANGLEMENT EVALUATION

RPT-001-006

MARINE SEISMIC SYSTEM
EM CABLE AND DRILL PIPE
INTERFERENCE AND CABLE WRAPPING
EVALUATION
(PRELIMINARY INVESTIGATION)

(Job 00001, Task 210200)

25 September 1980

Prepared by: Evgeny M. Gershunov
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Approved by:
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Mgr. Struc/Naval Arch

Dr. N. Daoud

S. Wetmore
VP Engineering

I-2

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1.0 ABSTRACT

A simplified scenario of possible interferences and cable wrapping is developed in this study to describe the problems associated with deployment of the Marine Seismic System. Due to major sources of excitations which include steady ocean current and effects of dynamic vessel motion, the EM cable may deflect and cross the drill pipe. If this happens, the probability of the cable wrapping will increase due to the secondary effects of unsteady disturbances. The operational parameters considered in the analysis are the applied top tension on the EM cable and the relative orientation of the drill pipe/EM cable system to the vessel and environmental source of excitations. The analysis is based on quasi-static approach in which dynamic effects are included in a steady manner. The major source of excitations are considered in the analysis, while the unsteady effects are lumped in the definition of an EM cable wrapping zone which separates the drill pipe and EM cable at all times.

2.0 OBJECTIVES

The objective of this study is to provide engineering information related to the deployment procedure of the MSS concept so that EM cable entanglement can be avoided.

3.0 DESIGN REQUIREMENTS

Design requirements of the drill pipe (DP) are listed in Reference (1). The main characteristics of the EM cable are (Reference 2):

- outside diameter is 0.692 inches
- total length is 34,000 ft
- breaking strength is 21,000 lbs
- tentative design load is 16,000 lbs
- dry weight per unit length is 0.51 lbs/ft
- wet weight per unit length is 0.33 lbs/ft
- longitudinal stiffness (product of modulus of elasticity and cross sectional area EA) is 2×10^6 lbs.

The steady current profile is assumed linear with velocity at the surface of 2 knots and decaying to zero at the sea bottom.

The distance a (FIG. 1) between the upper ends of the DP and EM cable at "GLOMAR CHALLENGER" is 92 ft.

4.0 SUMMARY OF RESULTS

The main results of this preliminary investigation are summarized below.

- Three necessary conditions are required for cable entanglement to take place:
 1. cable and drill pipe interference,
 2. cable wrapping about the drill pipe,
 3. nonzero tension applied to the inflection point of the cable within the wrapping zone (FIG.3)

- Main sources of excitation which may cause interference of the EM cable and DP are: current, ocean waves, vessel motion (Section 5.1).

- Wave loads applied to the EM cable are concentrated near the water surface and can be neglected (Section 5.1).

- EM cable behavior may be described by means of a uniform STRING model with constant or variable tension in it (Section 5.7).

- A quasi-static approach is developed to predict operational limits of the deployment procedure which minimize the probability of entanglement (Section 5.8).

- Two operational parameters affect the entanglement problem:

 1. relative orientation of the DP and EM cable with respect to environmental excitations,

 2. top tension applied to the EM cable.

- General static response of the EM cable is developed (Section 5.7.1) and the lower and upper limit of tension were determined (FIG. 6 and 7). These results are based on a string model with constant tension in the cable.

- Analysis of a static response of the cable was developed. This analysis is based on the string model with variable tension in it (Section 5.7.2).

- Geometry of the wrapping zone of the cable is described (Section 5.9.1) and it was shown the necessity of the inflection point to exist.

- Frictional resistance of the wrapped section of the cable depends on the friction coefficient, total angle of the EM cable wrapping round the Drill Pipe and tension applied to the inflection point. Analysis of this problem was developed and it was shown that solution may be expressed in another way using the total length of the wrapped section of the cable, drill pipe outside diameter, and the value of pitch of the wrapped line (Section 5.9.2).

- Friction coefficient substantially affects the friction resistance of the wrapped cable (Section 5.9.2). Additional information based on reliable experimental data related to this coefficient is required (Section 5.9.3).

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- In case when no tension is applied to the inflection point, the wrapped configuration of the EM cable is unstable. It means that no additional tension is required to unwrap the cable and to return it to its initial unwrapped disposition (Section 5.9.4).

- Any random reason may create a tensile force at the inflection point. The probability of this occurence should be investigated additionally. This investigation must be based on relaible information about DP and EM cable covers and the configuration of the connections between two sections of the DP.

- In case indicated above the additional tension to unwrap the cable was determined and results were presented in both analytical and graphical forms (Section 5.9.5). This additional tension substantially depends on the value of the tensile force applied to the inflection point.

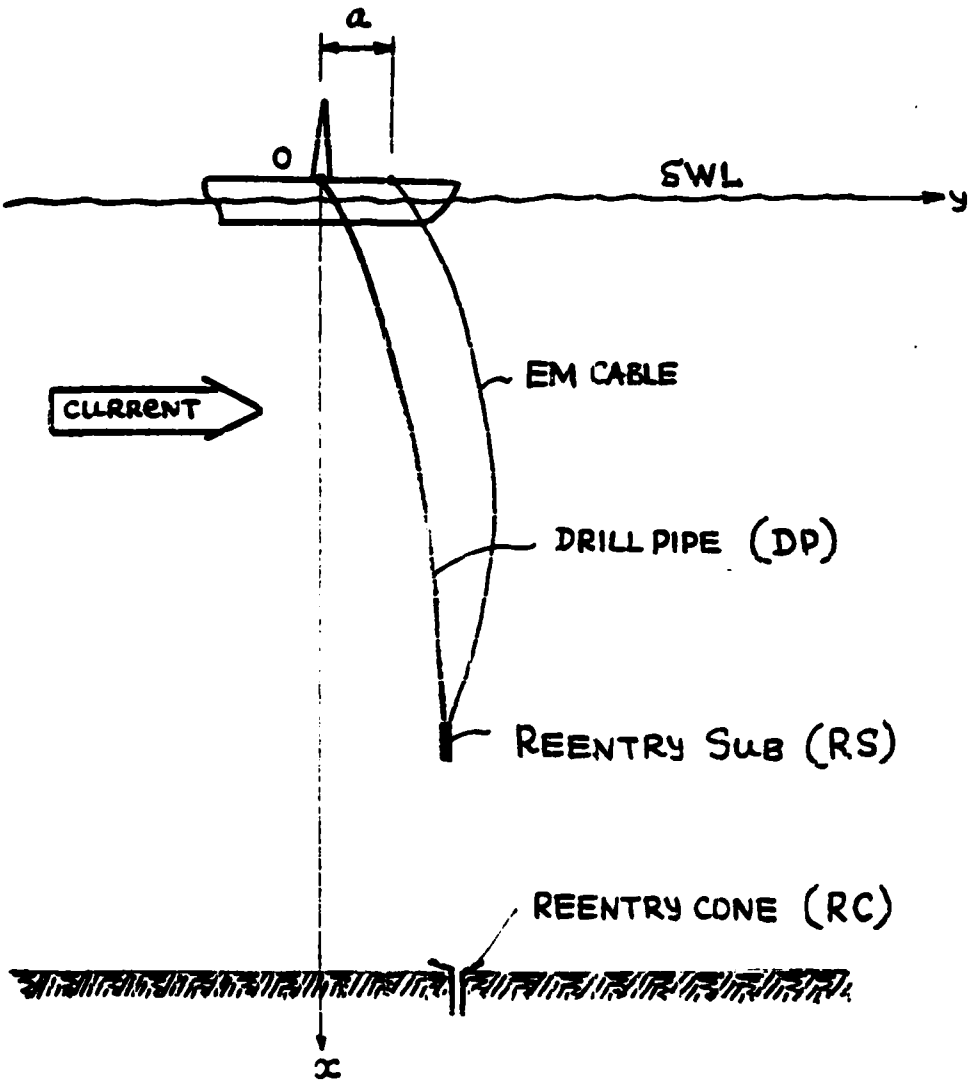


FIG. 1

MUTUAL DISPOSITION OF THE DRILL PIPE AND EM CABLE DURING THE REENTRY SUB INSTALLATION

I-10

5.0 TECHNICAL DISCUSSION

5.1 MAIN SOURCES OF EXCITATION

The proposed concept for deploying the BIP and implanting it into the borehole involves lowering the BIP on the end of a drill pipe with the EM cable attached to it and lowered separately from the top as shown schematically in Figure 1. The main sources of excitations acting upon the drill pipe and EM cable during deployment are:

- current,
- ocean waves,
- vessel motion.

These excitations may cause interference of the EM cable with the DP at one or more points and proable EM cable wrapping round the DP. Ocean current consists of steady unidirectional current, shear current and unsteady current.

Wave loads are concentrated mainly near the water surface and decay exponentially with depth (their effects diminishes approximately at distances greater than one half the wave length from the surface, which is very short relative to the total depth of the water). For this reason, direct wave forces are neglected in the analytical model. In addition, the drill pipe and EM cable are excited at the top by the dynamic motions

of the vessel. To simplify the analysis, these excitations are divided into two groups:

1. Major excitations, which contribute to the main deflection of both pipe and cable including the steady current effects and psudo-static effects of the dynamic motions of the vessel,

2. Unsteady distrubances, which contributes directly to entanglement and are due to unsteady sources of excitations that have a secondary effect on the deflected shapes of the pipe and EM cable.

5.2 DEFINITION OF CONDITIONS WHEN THE EM CABLE ENTANGLEMENT MAY OCCUR

There are three necessary conditions for entanglement to take place:

- cable and drill pipe interference (FIG. 2),
- cable wrapping about the drill pipe (FIG. 3),
- nonzero tension applied to the inflection point of the EM cable (FIG.3).

Consequently, the probability of the cable entanglement is related to the EM cable and DP interference at one or more points along the cable length as shown in FIG. 2.

Probable EM cable wrapping is displayed in FIG. 3. The third condition indicated above denotes that the cable within the wrapping zone should experience a nonzero tension.

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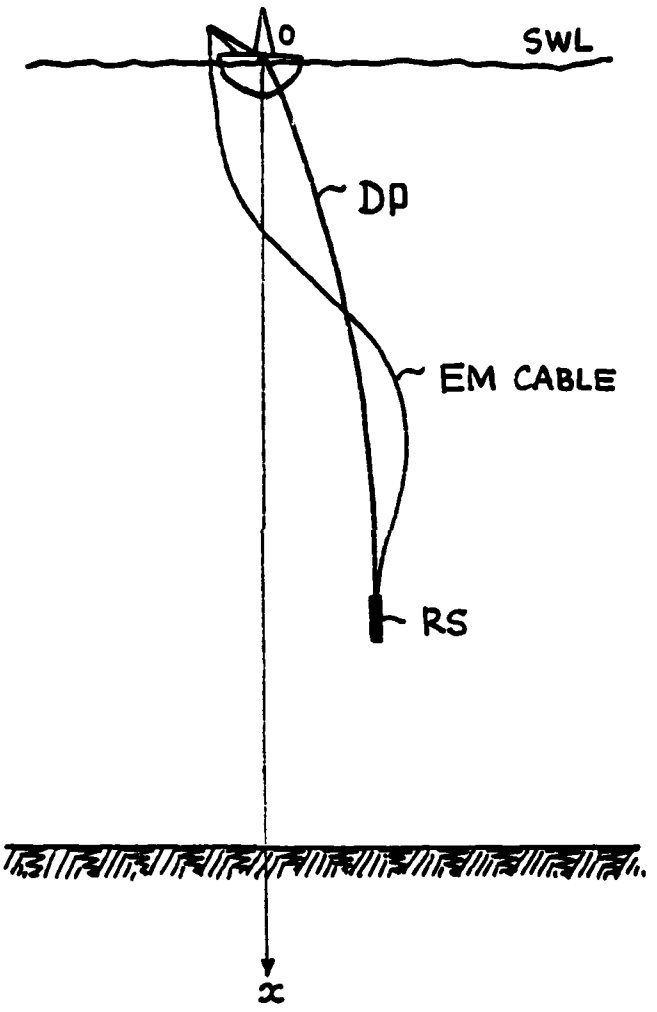


FIG. 2

SCHEMATIC INTERPRETATION OF THE EM CABLE AND DP INTERFERENCE

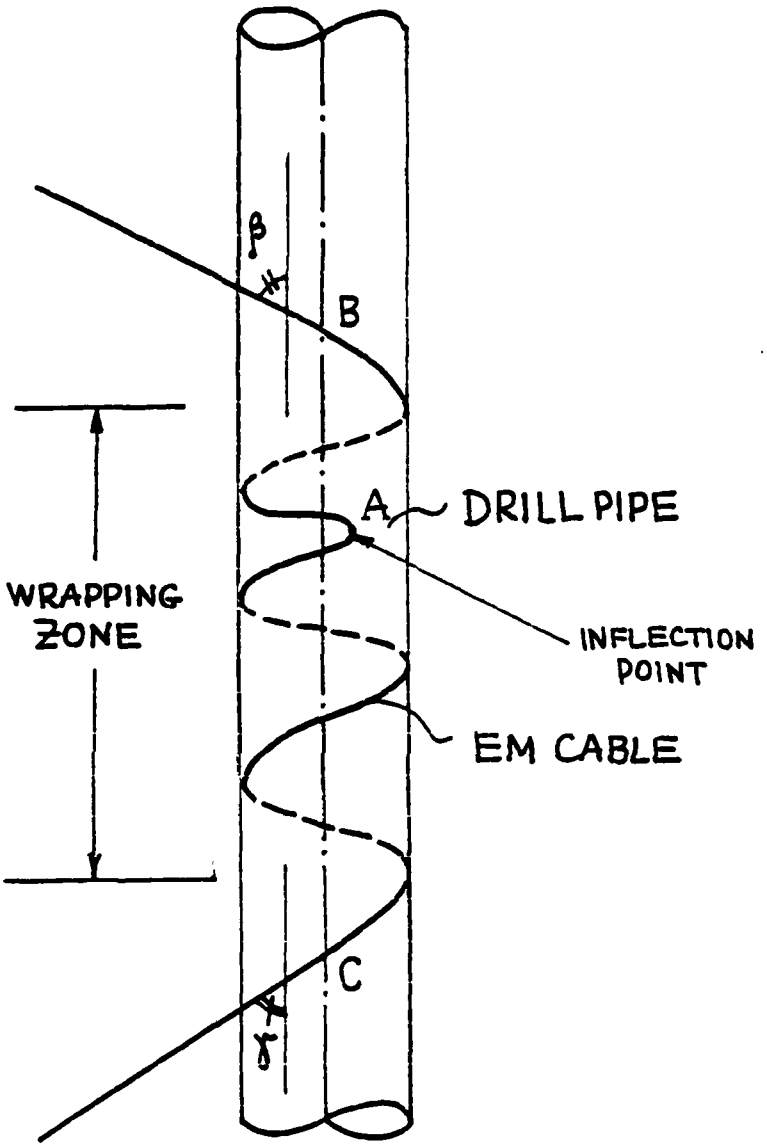


FIG. 3

EM CABLE WRAPPING ROUND THE DRILL PIPE

AB - UPPER LOOP, AC - LOWER LOOP, A - INFLECTION POINT,
β - WRAPPING ANGLE FOR THE UPPER LOOP,
γ - WRAPPING ANGLE FOR THE LOWER LOOP.

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5.3 METHOD OF SOLUTION

A direct approach for solving this complex problem is to obtain a time history of the responses of the drill pipe and EM cable based on time-step integration of their dynamic equations of motion. By inspection of the relative motions of the drill pipe and EM cable, entanglement can be predicted. But this approach is not suitable for parametric analysis of the deployment procedure because it requires costly computations in order to examine all possible variations in the operational and environmental conditions. The method can be used, however, as a final check for a particular deployment procedure. Another approach based on frequency domain analysis and statistical estimates of the responses was developed by Zsutty (Reference 3). This investigation was concerned mainly with the effect of ocean turbulance on the entanglement of vertical ropes. The method can be generalized to the present problem but the analysis is too complex for preliminary design purposes.

A simple quasi-static approach is developed in this section to predict operational limits of the deployment procedure which minimizes the probability of entanglement. The dynamic effects are evaluated approximately and incorporated in the static analy-

tical model of the system. Details of the analysis are discussed below.

5.4 OPERATIONAL PARAMETERS

It is assumed that the drill pipe operational characteristics and dimensions as well as the EM cable properties are fixed. The remaining parameters which affect the entanglement problem are:

- relative orientation of the drill pipe and EM cable with respect to environmental excitations,
- top tension applied to the EM cable,
- top separation between the drill pipe and EM cable denoted a in FIG. 1.

Variations of the last parameter are restricted due to practical considerations. Therefore, it is assumed fixed in the analysis.

5.5 CONDITION OF THE EM CABLE AND DRILL PIPE INTERFERENCE

To avoid the risk of entanglement, the EM cable should not be allowed to cross the drill pipe at any time. A more precise definition which is suitable for this proposed method of analysis is discussed below.

A conical zone surrounding the drill pipe with apex at the bottom end of the pipe is defined as the interference zone. This zone is fixed to the drill pipe

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and is allowed to deflect with it in such a way that the centerline of the pipe and the cone remain the same. In order to avoid interference, the EM cable is not permitted to cross this zone at any point due to the effect of the major sources of excitations as shown in Figure 4. This definition of entanglement can be expressed in mathematical form

$$|Y_p - Y_c| \geq E(x), \tag{1}$$

where

Y_p = deflection of the drill pipe at any point,

Y_p = deflection of the EM cable at the same point,

$E(x)$ = minimum allowable separation between the pipe and cable, which can be determined approximately by examing the envelopes of the dynamic motion of the drill pipe and EM cable.

The minimum separation E is introduced in the above definitions to account for the effects of the unsteady disturbances of the environment and dynamic responses since these effects are not included in evaluation of the elastic response of the system. The value of E(x) should be determined according to the measured intensity of the distrubances at the deployment location and the expected response of the system.

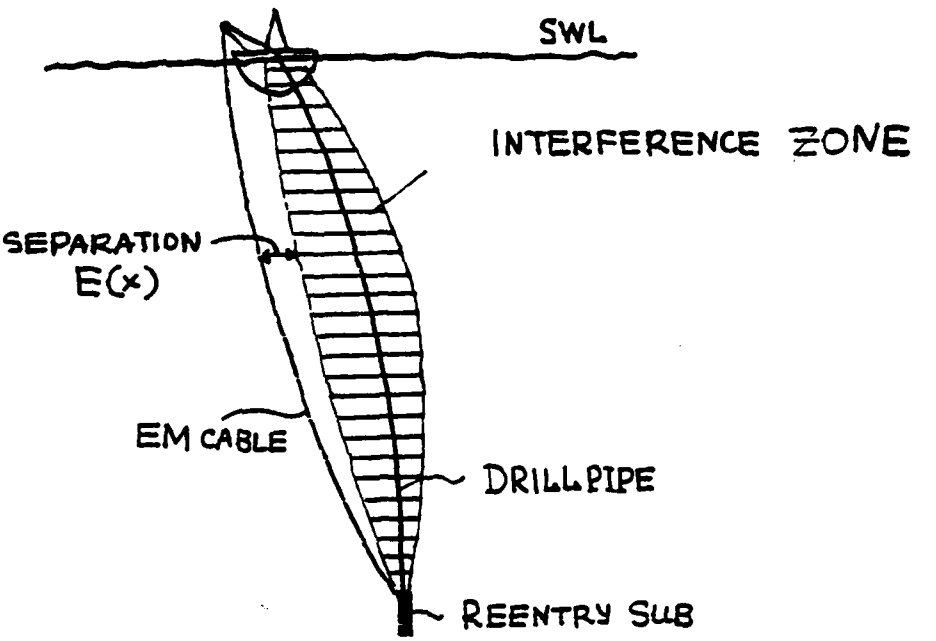


FIG. 4

DEFINITION OF INTERFERENCE ZONE

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5.6 ORIENTATION OF THE MAJOR EXCITATIONS

Define a right handed coordinate system with the origin fixed at the upper end of the drill pipe. For simplicity, the upper ends of the drill pipe and EM cable are assumed to lie on a horizontal line which is taken as the y-axis. The x-axis is vertical and positive downward as shown in Figure 5.
The current direction is defined in terms of its angle α with respect to the positive y-axis. The dynamic vessel motions are described in terms of three translational displacement of the origin O parallel to the above defined coordinate system and three rotational displacements about the axis of this coordinate system.

5.7 GENERAL STATIC RESPONSE OF THE EM CABLE

As discussed in Section 5.5 the deflections of the drill pipe and EM cable due to the major sources of excitation must be determined in order to evaluate entanglement. Deflections of the drill pipe are evaluated in a separate study and the results are reported in Reference 1. Therefore, this section is devoted to evaluation of the static response of the EM cable only. There are three methematical models which can be used to describe the behavior of the EM cable due to static forces applied to it, mainly:

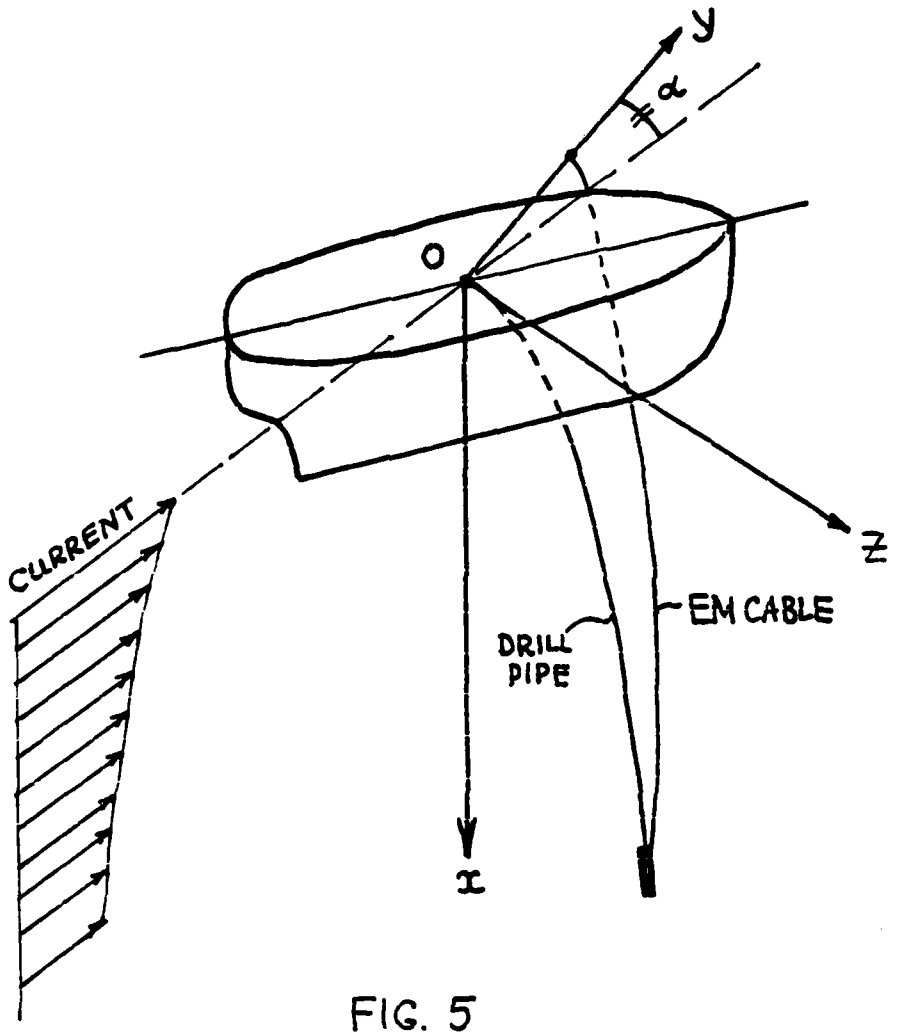


FIG. 5

COORDINATE SYSTEM

I-20

- STRING model,
- FUNICULAR model,
- CATENARY model.

STRING is defined as a straight slender beam with negligible bending stiffness, which is stretched between two points under a tension T. The tension can vary along the string and is the predominant loading source. The string can be subjected to lateral forces with arbitrary distribution along the model. This model is considered in the analysis within the framework of the assumption of small deflections for both static and dynamic loads.

FUNICULAR is a weightless string with some concentrated or arbitrary distributed lateral forces. Axial force is created only by lateral forces. This model may be considered in the framework of large deflections for both static and dynamic cases.

CATENARY is a freely suspended cable or chain under the action of its own weight which is uniformly distributed along the catenary length. The theory of large deflections is well developed. However, this model is not designed for describing lateral forces applied to it. Therefore, this model is not satisfactory in the case under consideration.

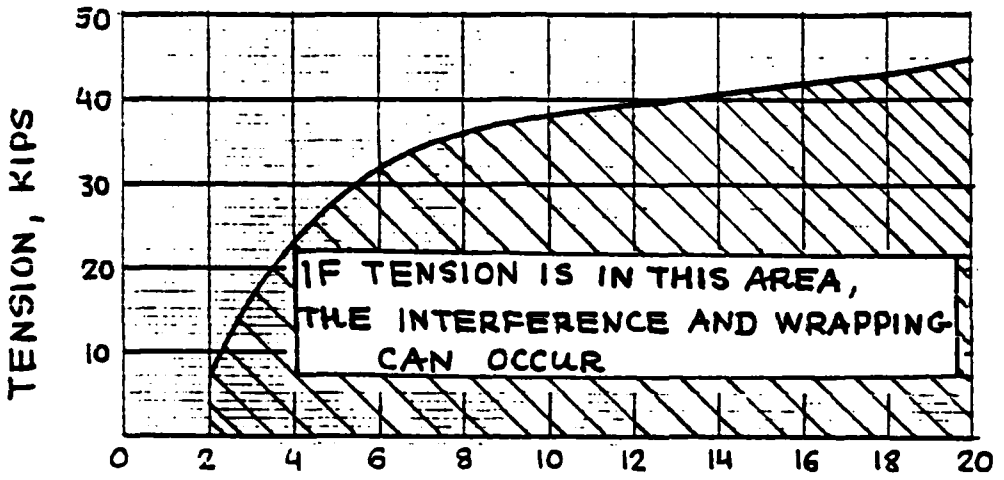
The FUNICULAR model assumes a weightless string. EM cable wet weight is 0.34 lbs/ft, which corresponds approximately to 30% of the value of the drag force at the top end of the cable. Hence, the cable weight can not be neglected.

Consequently, the string model with constant or variable tension is the most preferable calculation model to describe the behavior of the EM cable.

5.7.1 STRING MODEL WITH CONSTANT TENSION

Figures 6 and 7 represent the lower and upper limit of the EM cable tension to fullfill the requirement (1), Section 5.4. The only source of excitation is the current under consideration. It is assumed, the tension in the cable is constant and the cable-drill pipe system lies in the plane of current ($\alpha=0$ and $\alpha=180^{\circ}$, FIG.5). The information about the DP static behavior due to current was used from Reference 1. Since the tentative design 10ad in the cable is 16,000 lbs (Section 3), the mutual disposition of the cable-pipe system shown in FIG. 6, cannot be maintained due to high tension required. When the angle $\alpha=0$ (FIG.5 and 7), significantly lower tension is required to avoid the cable-pipe interference.

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ℓ = DRILL PIPE LENGTH, 1000 FT

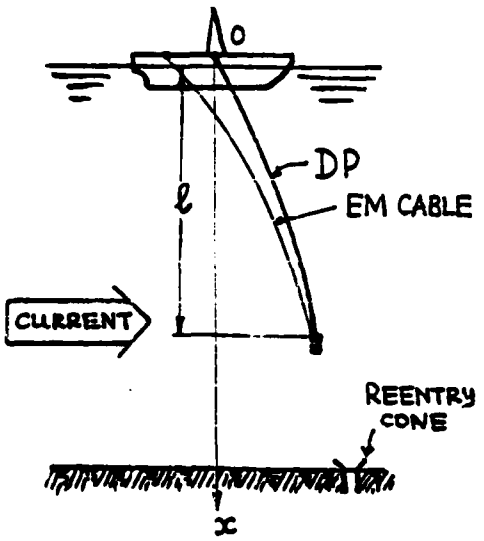
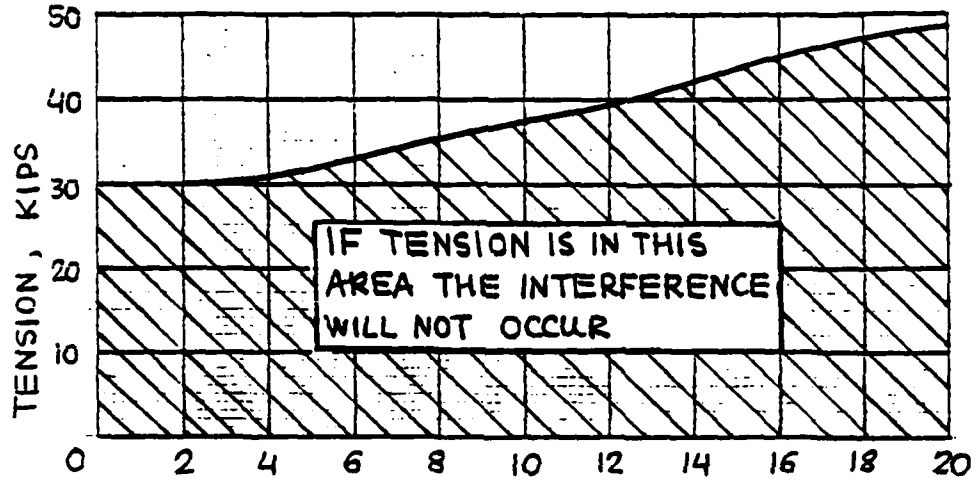


FIG.6

LOWER LIMIT OF TENSION IN THE EM CABLE AS A FUNCTION OF THE SUBMERGED LENGTH ℓ OF THE DRILL PIPE (DP) FOR LINEAR CURRENT PROFILE WITH 2 KN CURRENT AT THE SURFACE AND 0 AT THE OCEAN FLOOR.

($\alpha = 180°$)



ℓ = DRILL PIPE LENGTH, 1000 FT

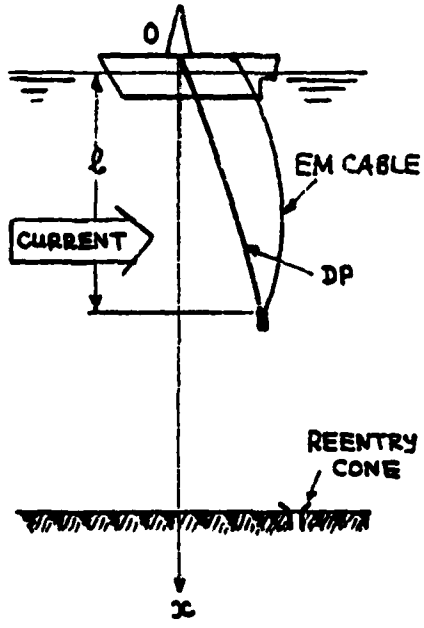


FIG. 7

UPPER LIMIT OF TENSION IN THE EM CABLE AS A FUNCTION OF THE SUBMERGED LENGTH ℓ OF THE DRILL PIPE (DP) FOR LINEAR CURRENT PROFILE WITH 2 KN CURRENT AT THE SURFACE AND 0 AT THE OCEAN FLOOR.

(α=0)

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5.7.2 STRING WITH VARIABLE TENSION IN IT

The differentail equation of a string model which represents the response of the EM cable is taken in the form:

$$\frac{dT(x)}{dx} = -W_c \ , \tag{1}$$

$$\frac{d}{dx}\left[T(x)\,Y'(x)\right] = -q_v(x) , \tag{2}$$

where

$T(x)$= variable tension along the cable,

$Y(x)$= lateral deflection of the cable,

$q_v(x)$= lateral load activug on the unit length of the cable.

W_c = wet weight of the cable per unit length.

Equation (1) can be integrated to obtain

$$T(x) = T_0 - W_c x . \tag{3}$$

Here T_0 denotes the tensile force applied to the upper end. Substituting the above expression for T in equation (2) and then integrating once, one obtains

$$Y'(x) = \left[B - \int q_v(x)dx\right]\left(T_0 - W_c x\right)^{-1},$$

where B is the constant of integration. The deflection can be obtained by integrating the above expression

$$Y(x) = A - \frac{1}{W_c}\log\left(T_0 - W_c x\right)\left[B - \int q_v(x)dx\right] - \frac{1}{W_c}\int q_v(x)\log\left(T_0 - W_c x\right)dx , \tag{4}$$

where A is a second constant of integration. The constants A and B will be determined from the specified displacements Y_0 adn Y_B of the top and bottom end of the cable, respectively,

$$Y_0 = Y(0), \quad Y_B = Y(L). \tag{5}$$

For a linear current profile which vanishes at the bottom of the ocean, it can be written

$$V(x) = V_0 \left(1 - \frac{x}{h}\right), \tag{6}$$

where

$V(x)$ = velocity of current at a distance x from the surface,

V_0 = current velocity at the surface,

h = depth of water.

The lateral loading $q_l(x)$ is defined as:

$$q_l(x) = \frac{1}{2} \rho C_D D [V(x)]^2, \tag{7}$$

where

ρ = mass density of water,

D = outside diameter of EM cable,

C_D = quadratic drag coefficient of the cable.

Therefore,

$$q_l(x) = q_0 \left(1 - \frac{x}{h}\right)^2, \tag{8}$$

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where

$$q_o = \frac{1}{2}\rho D C_D V_o^2 . \tag{9}$$

Equation (4) becomes:

$$Y(x) = A - \frac{1}{w_c}\log(T_o - w_c x)\left[B + \frac{q_o h}{3}\left(1 - \frac{x}{h}\right)^3\right] +$$

$$+ \frac{q_o}{w_c^2}\left[1 - \frac{T_o}{w_c h} + \frac{T_o^2}{3w_c^2 h^2} - \frac{x}{h}\left(1 - \frac{T_o}{3w_c h}\right) + \frac{x^2}{3h^2}\right] \times$$

$$\times (T_o - w_c x)\log(T_o - w_c x) + \frac{q_o}{w_c}\left[x\left(1 - \frac{T_o}{w_c h} + \frac{T_o^2}{3w_c^2 h^2}\right) - \right.$$

$$\left. - \frac{x^2}{2h}\left(1 - \frac{T_o}{3w_c h}\right) + \frac{x^3}{9h^2}\right]. \tag{10}$$

The constants A and B are determined by satisfying the boundary conditions presented in relations (5).

5.8 APPROXIMATE EVALUATION OF THE DYNAMIC EFFECTS

Generally, the dynamic response of the EM cable can be obtained from the frequency domain solution of its dynamic equations of motion. For a given input spectrum of the excitations, statistical methods can be used to evaluate the maximum expected envelope of the cable deflections. However, the inertial effects of the cable are negligibly small due to its smallness per unit length and, consequently, the resulting deflections are proportionally small except when the excitation frequencies are close to the natural frequency of the cable. Even for these discrete

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frequencies integration over the spectrum will smooth their effects.

Therefore, the EM cable is modeled dynamically as a elastic body attached to the ship. While the inertial effects and the resulting dynamic deflection can be included in the evaluation of the required entanglement zone.

Dynamic excitations due to vessel motion are assumed to be provided in terms of maximum expected values of the three translational acceleration of the point 0 (origin of coordinates) a_x, a_y, a_z parallel to the given coordinate axis x,y,z, respectively, and the corresponding values for the rotational accelerations $\alpha_x, \alpha_y, \alpha_z$ and velocities $\omega_{x,y,z}$ about the x, y, z axes, respectively. The main effect of these dynamic excitations according to the above assumption is a modification of the used weight per unit length of the cable W_c and the lateral load $q(x)$ in the static model. Based on the assumption of small deflection, upper and lower bounds of the modifications are:

$$W_m = W_c \pm \frac{W_c}{g}\left[a_x + 0.5L\left(\omega_z^2 + \omega_y^2\right)\right],$$

$$q_m = q(x) \pm \frac{W_c}{g}\left(a_y + \alpha_z x\right),$$

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where

W_m = modified weight per unit length due to dynamic effects,

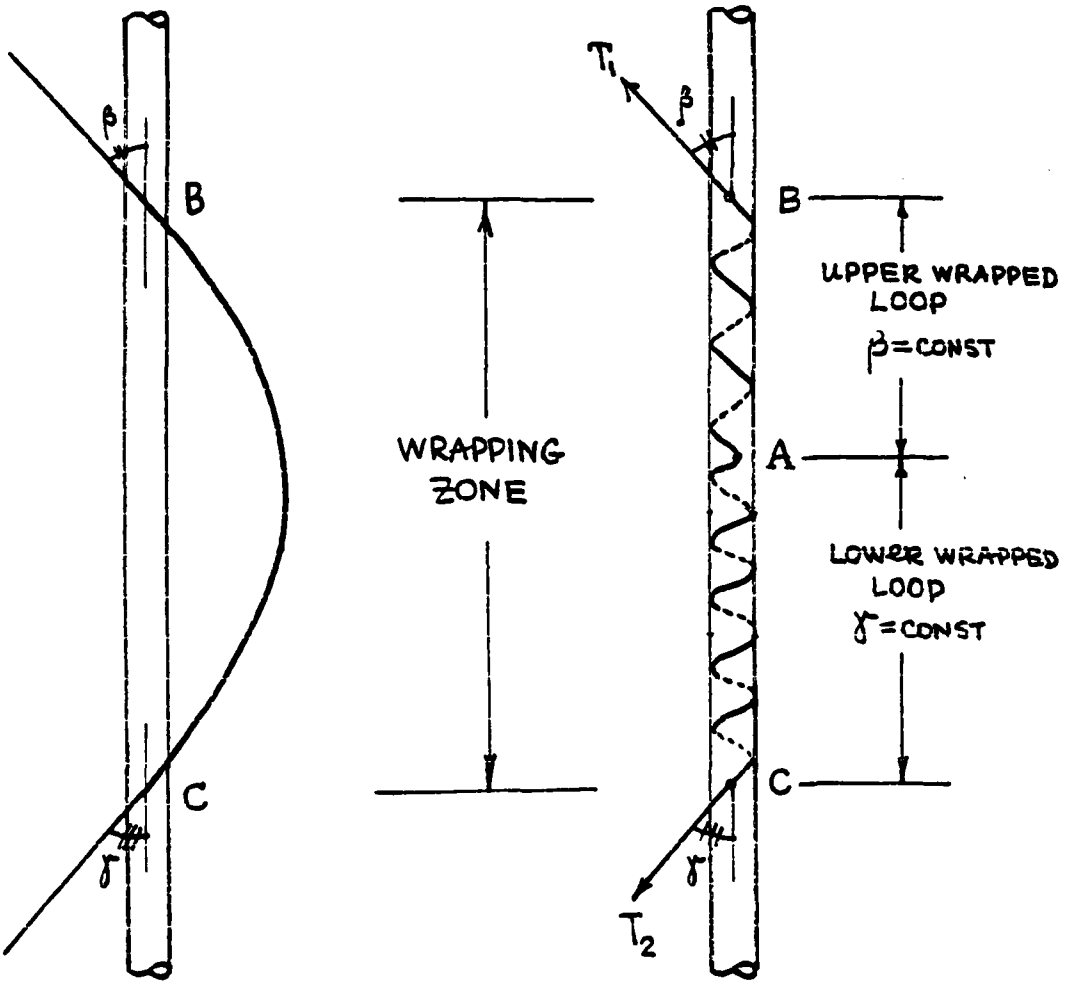
q_m = modified lateral load percent length due to dynamic effects.

The plus and minus signs are used in the above equations to determine both bounds of the dynamic effects.

5.9 ADDITIONAL TENSION NECESSARY TO UNWRAP THE EM CABLE IN CASE OF WRAPPING

5.9.1 WRAPPING GEOMETRY

Assume, that before wrapping the EM cable crossed the DP as it is shown in FIG. 8 in two points A and C with angles β and γ , respectively. Assume, also that any forces caused EM cable wrapping round the drill pipe. The wrapped section of the cable may be divided on two parts: upper wrapped loop between B and the inflection point A, and lower loop between C and A. Since there is no vertical components of the exciting forces, the angles between the cable and the generator of the drill pipe surface remain constant within every loop, i.e. β for the upper loop, γ for the lower one. Number of pitches depends upon the length of the wrapped cable, angles β and γ , tension in the upper and lower ends of the wrapped section of the cable, and drill pipe outside



EM CABLE AND DP DISPOSITION BEFORE WRAPPING

EM CABLE WRAPPED ROUND THE DRILL PIPE

FIG. 8

EM CABLE AND DRILL PIPE BEFORE AND AFTER CABLE WRAPPING

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diameter. The load causing wrapping is assumed to be uniformly distributed along the cable within the section AB (FIG.8).

Point A where two loops are connected is called here the inflection point. Existing of this point is necessary if the wrapping problem occurs.

5.9.2 FRICTIONAL RESISTANCE OF THE WRAPPED SECTION OF THE CABLE

The question is how much additional tension is required to unwrap the cable within the wrapping zone. To investigate the problem, divide the wrapped length of the cable on two parts AB and AC (FIG. 8) and consider one of them, for instance, the upper loop AB (FIG.9). Let T_1 and T_0 denote the tensile forces applied to the upper and lower ends of this loop. Consider the equilibrium of any element of the cable length ds located at the angle θ from the point of tangency A. A free-body diagram of this element showing all the forces acting upon it is given in FIG. 9 The equations of equilibrium become

$$\begin{aligned} \Sigma X=0,&\quad -(T+dT)\sin\beta + T\sin\beta + dF\cdot\sin\beta = 0,\\ \Sigma Y=0,&\quad dN - T\frac{d\theta}{2} - (T+dT)\frac{d\theta}{2} = 0,\\ \Sigma Z=0,&\quad T\cos\beta - (T+dT)\cos\beta + dF\cdot\cos\beta = 0. \end{aligned} \tag{1}$$

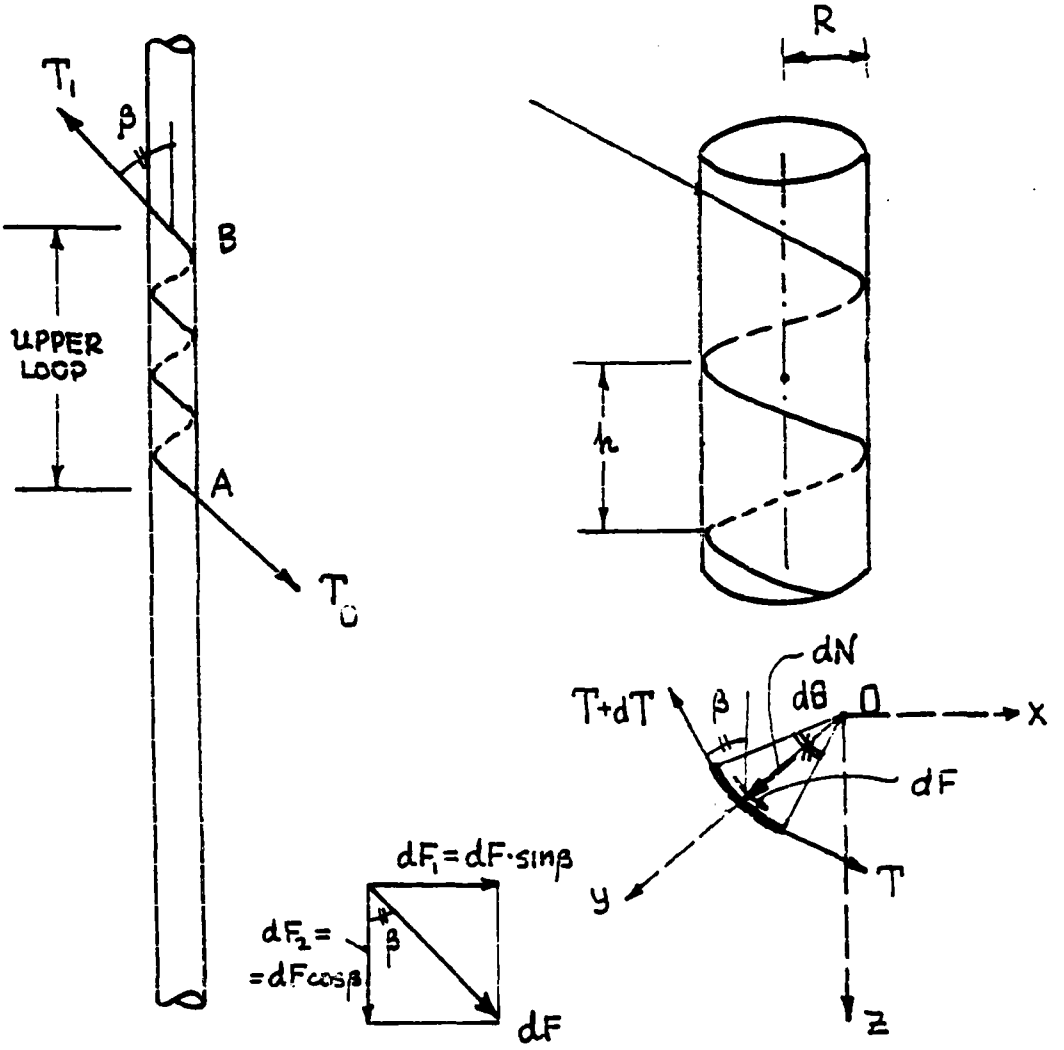


FIG. 9

CALCULATION SCHEME FOR UNWRAPPING PROBLEM

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Neglecting small quantities of second order, the first two equations reduce to

$$dT=dF\,,\quad dN=Td\theta. \tag{2}$$

The third equation (1) gives the same result $dT=dF$. When slipping impends, the relation

$$dF=\mu dN\,, \tag{3}$$

where μ denotes the friction coefficient, should be satisfied. Combining equations (2) with relation (3), one can obtain differential equation

$$\frac{dT}{T}=\mu d\theta \tag{4}$$

with respect to unknown tension T in the EM cable. Integrating this equation over the entire line of contact AB (FIG. 9), that is from $\theta=0$ to $\theta=\varphi$, one obtains

$$T_1=T_0 e^{\mu\varphi}\,, \tag{5}$$

where φ is measured in radians.
The EM cable will be on the point of slipping from A toward B by reason of the difference of tension T_1-T_0. Then, T_1-T_0 is equal to the circumferential force P transferred by friction. Meantime, the difference T_1-T_0 must be equal to the frictional resistance

W of the EM cable. Consequently,

$$P=W=T_1\left(1-e^{-\mu\varphi}\right)=T_0\left(e^{\mu\varphi}-1\right). \qquad (6)$$

This relation shows how the force which can unwrap the cable depends upon the total wrapping angle φ, friction coefficient μ, and tension T_0 applied to the inflection point A of the wrapping section of the cable.

Relation (6) can be presented in another form. If the total length of the upper wrapped loop is ℓ, the pitch of the loop is h (FIG. 9) and the outside radius of the drill pipe is R, then the total angle of wrapping may be written in the form

$$\varphi=\frac{\ell}{\rho},$$

where ρ denotes the radius of curvature of the upper loope line (Reference 6)

$$\rho=\frac{R^2+h^2}{R}.$$

Consequently, expression (6) may have the following form:

$$P=W=T_1\left(1-e^{-\mu\frac{\ell R}{R^2+h^2}}\right)=T_0\left(e^{\mu\frac{\ell R}{R^2+h^2}}-1\right). \qquad (7)$$

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Either expressions (6) or (7) may be used for practical calculations. It should be pointed out that the angle β (FIG. 9) does not affect the frictional resistance of the wrapped cable. However, the total wrapped length ℓ does affect it substantially.

5.9.3 FRICTION COEFFICIENT

Friction coefficient μ depends on the surfaces of the cable cover and drill pipe and the material they are manufactured from. It was assumed that the cable cover was made from teflon and the drill pipe has a steel surface. According to References 4 and 5, the value of the friction coefficient between teflon and steel surfaces can be taken in the range of $0.04 \leq \mu \leq 0.05$. For the problem under consideration at least two additional circumstances should be pointed out:

- the outside surface of the drill pipe has some synthetic anticorrosion coating,
- both surfaces (cable and pipe) are lubricated by embient water.

These circumstances will substantially decrease the value of the μ coefficient. For concervative evaluation of the frictional resistance of the wrapped section of the cable the friction coefficient was taken here equal to 0.04. For final analysis this coefficient should be determined by means of more sophisticated approach based on reliable information regarding to cable and pipe covers.

5.9.4 ADDITIONAL TENSION IN CASE WHEN NO TENSION IS APPLIED TO THE INFLECTION POINT

The main result from expression (6) (Section 5.9.2), is: If $T_o=0$, in other words, if there is no tension applied to the inflection point A, no additional tension is required to unwrap the cable. It means, that to maintain wrapping, a nonzero tensile force must be applied to the inflection point of the wrapped section of the cable. Neither current, nor waves or vessel motion can produce such kind of force. Consequently, the wrapped cable configuration is unstable and the regular tensile force will return it to its initial unwrapped disposition.

5.9.5 ADDITIONAL TENSION IN CASE WHEN ANY NONZERO TENSION IS APPLIED TO THE INFLECTION POINT

If any random reason, what should be checked by a simple experiment, can generate the force T_o at the inflection point, additional force should be applied to unwrap the cable. FIG. 10, presents the relationship between the total angle of wrapping φ for the upper wrapped loop and the force P transferred by cable friction ($\mu=0.04$, Reference 4)

$$\frac{P}{T_o}=\frac{W}{T_o}=e^{\mu\varphi}-1. \qquad (8)$$

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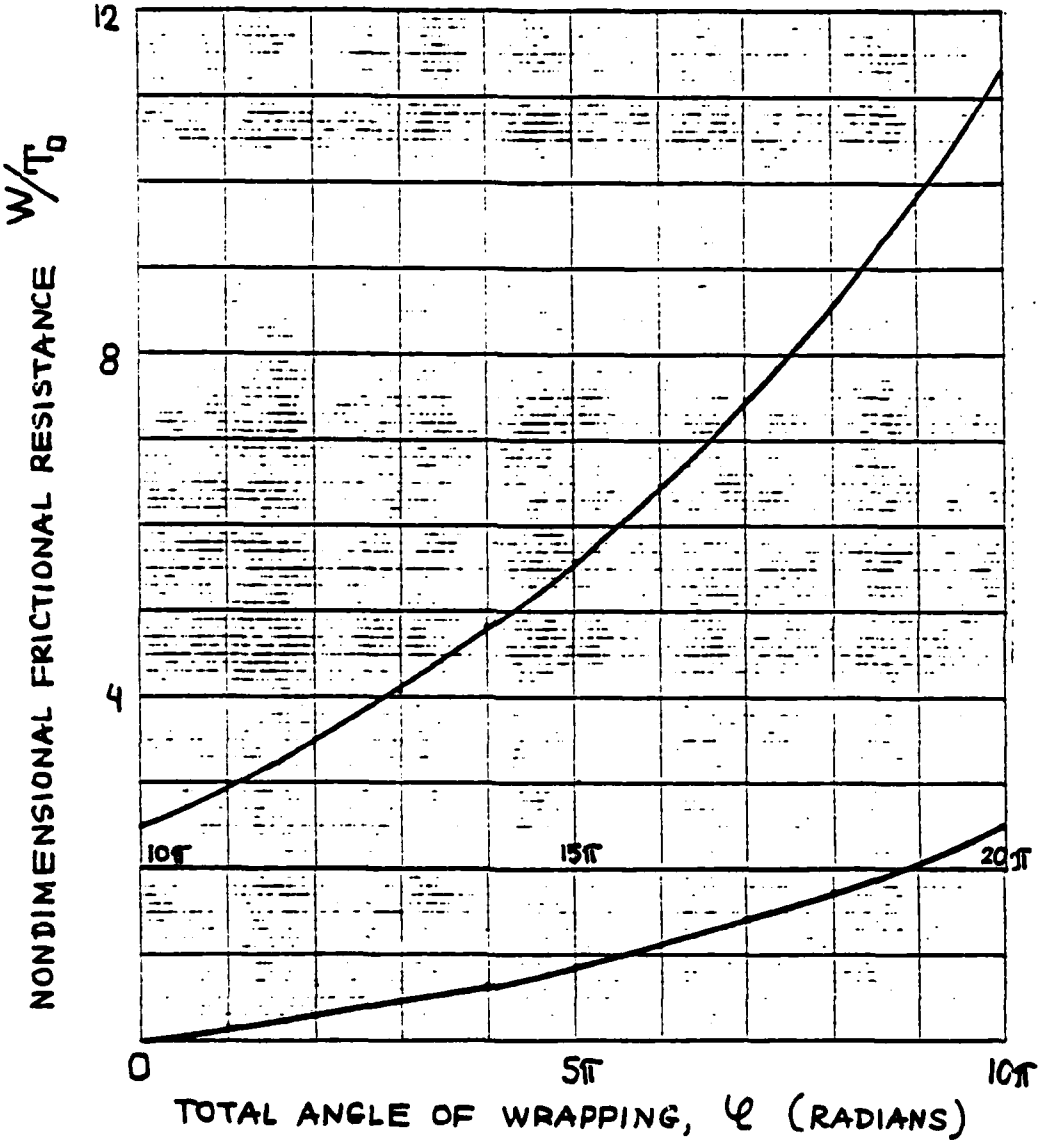


FIG. 10

NONDIMENSIONAL FRICTIONAL RESISTANCE OF THE WRAPPED SECTION OF THE EM CABLE BETWEEN EITHER END AND THE INFLECTION POINT.

Assume now, that the force $T_1 = T_0 + P$ is applied to unwrap the upper loop (FIG. 8). Considering the lower loop and repeating the above reasoning, one can find

$$\frac{W_1}{T_2} = \frac{P_1}{T_2} = e^{\mu\varphi_1} - 1, \tag{9}$$

where

W_1 = frictional resistance of the lower loop,

P_1 = force transferred by cable friction along this loop,

φ_1 = total wrapped angle,

T_2 = tension applied to the lower end at the point C (FIG. 8)

So, to unwrap the lower loop the force

$$T = T_2 + P_1 \tag{10}$$

should be applied. It should be added, that the force T_2 can be created only by current and the dead weight and accomplish the maximum value by unidirectional current. To evaluate this force T_2 an additional problem of the cable equilibrium below the wrapping zone should be considered. Then FIG. 10 can be used to evaluate the force T necessary to unwrap the lower loop. Approximate evaluation shows that the force applied to the upper end B (FIB. 8) exceeds the value required by relation (9). That is why, in most cases of wrapping with nonzero tension at the inflection point A (FIG. 8), the force T_1 ensures unwrapping

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both the upper and lower loops of the wrapped section of the cable.

5.10 CONCLUSION AND RECOMMENDATIONS

Conclusion and recommendations of this study, basically, are formulated in Section 4.0 "Summary of Results". It should be noted once more that for the stage of final design the following problems should be considered:

- More sophisticated definition of the friction coefficient. This subject is recommended to be checked by experiment.
- Probability of existing nonzero tension applied to the inflection point of the wrapped section of the cable.
- Numerical information related to:
 1. static response of the EM cable based on the string model with variable tension in it,
 2. dynamic response of the EM cable based on the same model due to ship excitation. Some results from Reference 7 may be useful to investigate this problem as well the static response,
 3. effect of ship orientation with respect to to the direction of current and waves,
 4. value of the tensile force (if any) occuring at the inflection point of the wrapping zone of the cable.

APPENDIX I-2

CABLE TENSIONING FACTORS

I-2 CABLE TENSIONING FACTORS

The forces generated with 20,000 and 500 ft of cable were also reviewed and the results of both studies are tabulated below:

FACTORS	CABLE LENGTH (FT) 20,000 Ft.	500 Ft.
	CABLE TENSION (LBS)	
Minimum Tension	1,500	1,500
Cable Weight	6,667	167
Current Drag Induced Tension	1,250	255
TOTAL - STATIC	9,417	1,922
Roll Induced Tension - Stretch	157	5,822
Pitch Induced Tension - Stretch	529	19,571
COMBINED PITCH & ROLL-STRETCH (NOT ADDITIVE)	686	25,405
Roll Induced Tension - Inertia	106	266
Pitch Induced Tension - Inertia	1,110	28
Heave Induced Tension - Inertia	639	16
TOTAL - DYNAMIC (INERTIA)	1,855	310
MAXIMUM LOADING	11,958	27,637

APPENDIX J

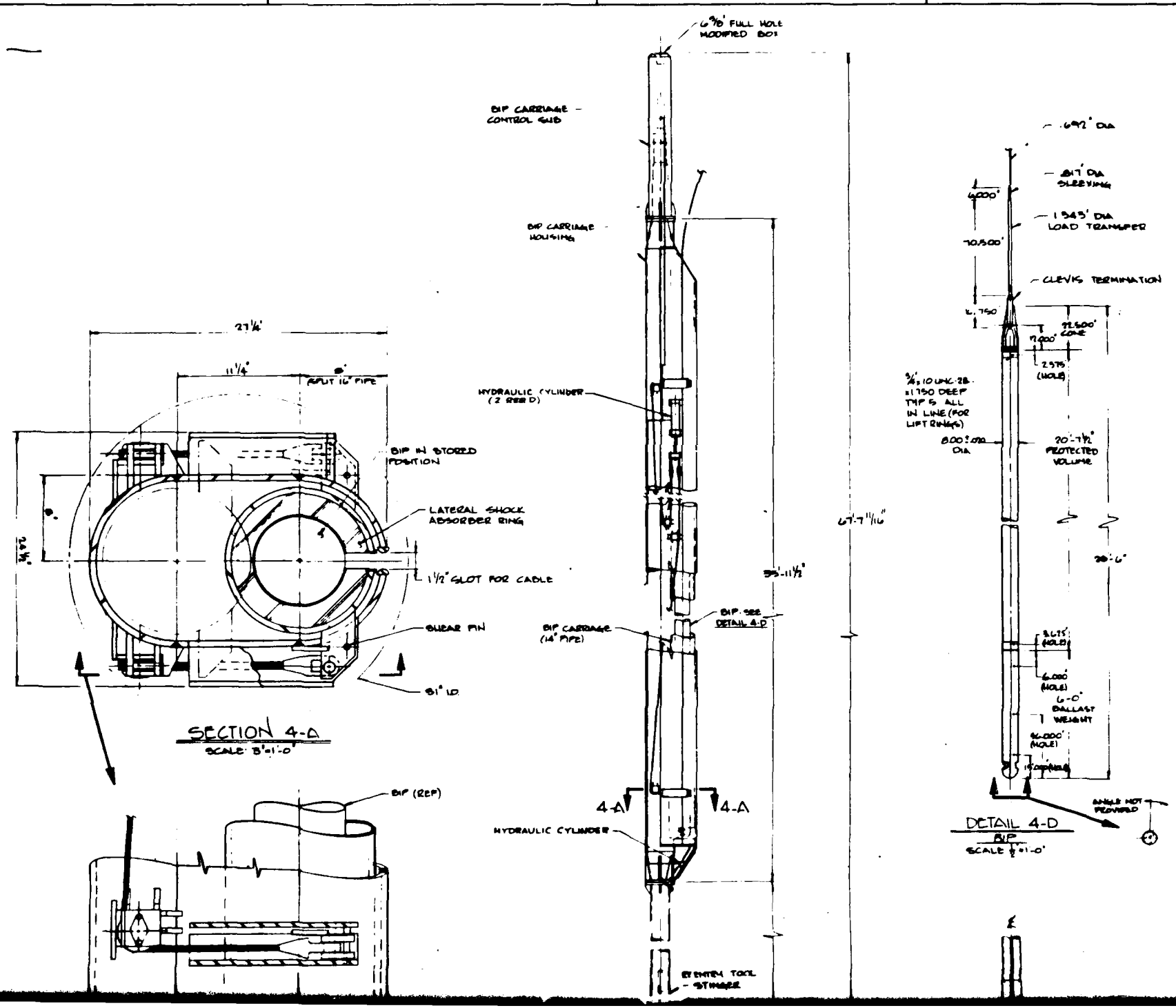
AT-SEA-TEST DRAWINGS

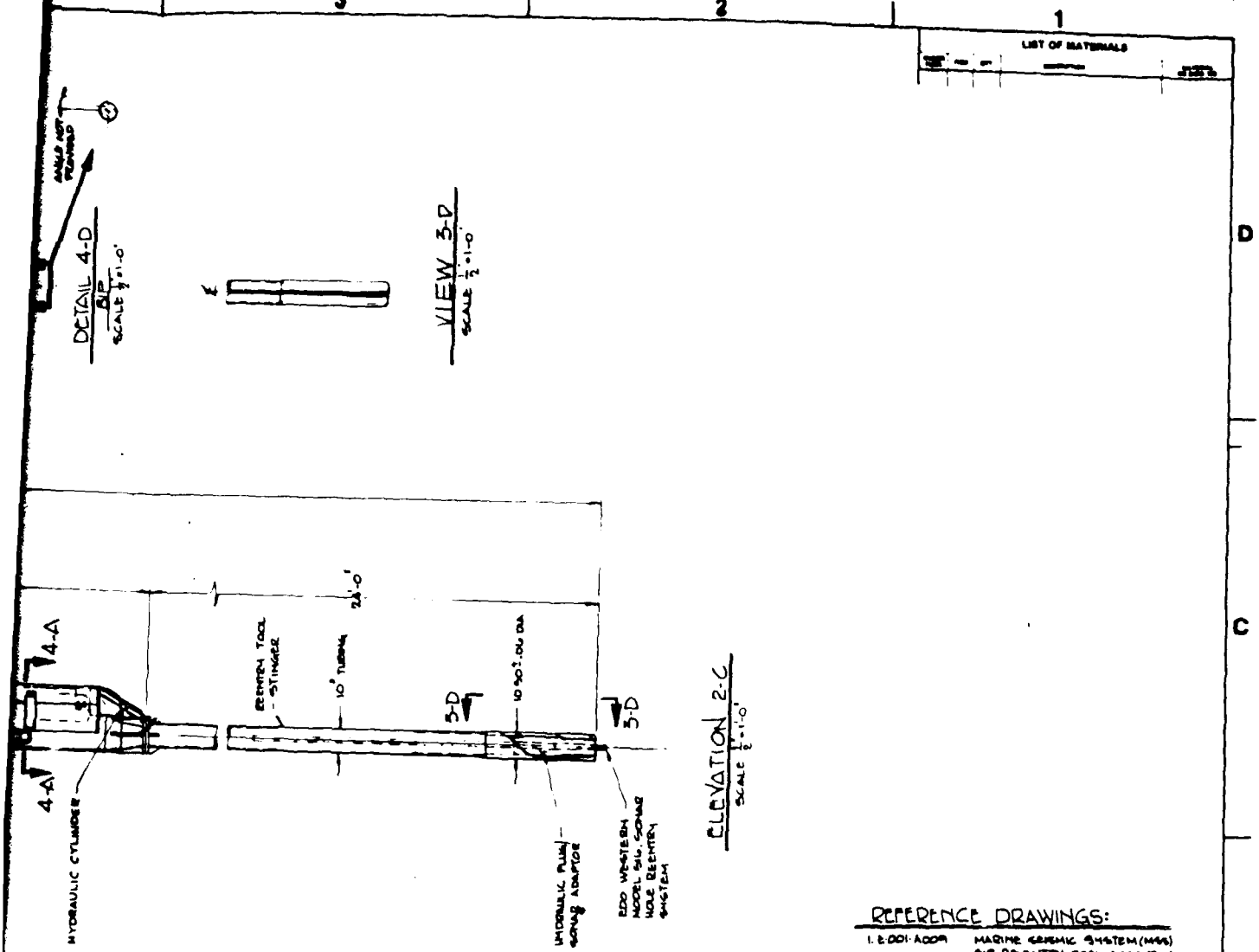
LIST OF DRAWINGS

DRAWING NO.	TITLE
E-001-A001	BIP REENTRY SUB WITH STINGER CONTROL DRAWING
E-001-A002	REENTRY ASSEMBLY CONTROL DRAWING
E-001-A003	BIP CARRIAGE CONTROL SUB DETAILS AND ASSEMBLY
D-001-A004	BIP CARRIAGE ASSEMBLY AND DETAILS
E-001-A005 (2 SHTS)	BIP CARRIAGE HOUSING ASSEMBLY AND DETAILS
C-001-A006	LATERAL SHOCK ABSORBER RING DETAIL
D-001-A007	REENTRY TOOL STINGER ASSEMBLY AND DETAILS
E-001-A008	BIP CARRIAGE HOUSING MAIN ASSEMBLY
E-001-A009	BIP REENTRY TOOL ASSEMBLY
D-001-A010	HYDRAULIC PLUG/SONAR ADAPTOR DETAILS
E-001-A011 (3 SHTS)	EM CABLE A-FRAME ARRANGEMENT AND DETAILS (Drawing in Process - To be submitted in final release.)
E-001-A012	TIE DOWN AND FOUNDATION FOR VAN AND WINCH ARRANGEMENT AND DETAILS (Drawing in Process - To be submitted in final release.)
E-001-A013	MARINE SEISMIC SYSTEM (MSS) EM CABLE PROTECTOR DETAILS & ASSEMBLY

LIST OF DRAWINGS
(Continued)

DRAWING NO.	TITLE
E-001-A014	MARINE SEISMIC SYSTEM (MSS) EM CABLE PROTECTOR INSTALLATION ARRANGEMENT
E-001-A018	MARINE SEISMIC SYSTEM (MSS) HEAVE COMPENSATOR CONTROL BOARD, DETAILS & ASSEMBLY
E-001-A020	MARINE SEISMIC SYSTEM (MSS) INSTRUMENTATION & CONTROLS INSTALLATION
E-001-A022	MARINE SEISMIC SYSTEM (MSS) A-FRAME DETAILS & ASSEMBLY
E-001-A023	MARINE SEISMIC SYSTEM (MSS) A-FRAME SUPPORT TO SUB BASE DETAILS & ASSEMBLY
E-001-A024	MARINE SEISMIC SYSTEM (MSS) A-FRAME SUPPORT TO CASING RACK DETAILS
E-001-A025	MARINE SEISMIC SYSTEM (MSS) WINCH FOUNDATION DETAILS & ARRANGEMENT
E-001-A028	MARINE SEISMIC SYSTEM (MSS) GLOMAR CHALLENGER EQUIPMENT INSTALLATION ARRANGEMENT
E-001-A030	MARINE SEISMIC SYSTEM (MSS) ACCUMULATOR SUPPORTS DETAILS & ASSEMBLY
E-001-P001	MARINE SEISMIC SYSTEM (MSS) HEAVE COMPENSATOR PIPING DIAGRAM


6 3/8" FULL HOLE MODIFIED BOX
BIP CARRIAGE - CONTROL SUB
BIP CARRIAGE HOUSING
HYDRAULIC CYLINDER (2 REQ'D)
BIP CARRIAGE (14" PIPE)
BIP. SEE DETAIL 4-D
HYDRAULIC CYLINDER
67'-7 11/16"
35'-11 1/2"
4-A
4-A
RETAINER TOOL - STINGER
.692" DIA
.817" DIA SLEEVING
4.000"
1.343" DIA LOAD TRANSFER
70.500"
CLEVIS TERMINATION
4.750
12.500" CONE
11.000"
2.375" (HOLE)
3/8"-10 UNC-2B - 1.750 DEEP TYP 5 ALL IN LINE (FOR LIFT RINGS)
8.00" DIA
20'-7 1/2" PROTECTED VOLUME
20'-6"
8.625" (HOLE)
6.000" (HOLE)
6'-0" BALLAST WEIGHT
6.000" (HOLE)
ANGLE NOT PROVIDED
DETAIL 4-D
BIP
SCALE 1/2"=1'-0"
27 1/4"
11 1/4"
8"
SPLIT 16" PIPE
BIP IN STORED POSITION
LATERAL SHOCK ABSORBER RING
1 1/2" SLOT FOR CABLE
SHEAR PIN
81" I.D.
SECTION 4-A
SCALE 3"=1'-0"
BIP (REF)

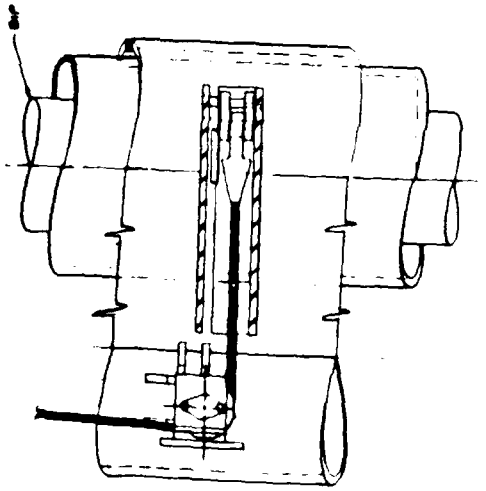


REFERENCE DRAWINGS:

1. E-001-A009 MARINE SEISMIC SYSTEM (MSS) DIP RE-ENTRY TOOL ASSEMBLY

TELEDYNE GEOTECH DRAWINGS

2. 990-5300 DIP
3. 990-5300-0101 DIP LAYOUT



2		CHG MOD CYL PLACEMENT, MOD CABLE RUN & ADDED DIP PICK UP POINTS	
1		REVISED PER ECO PACKAGE	
0		INITIAL RELEASE	
B		RE-DESIGNED & RE-DRAWN	
A		PRELIMINARY RELEASE	

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[redacted]

MARINE SEISMIC SYSTEM (MSS)
DIP RE-ENTRY SUB WITH STINGER - CONTROL DRAWING

NOTED

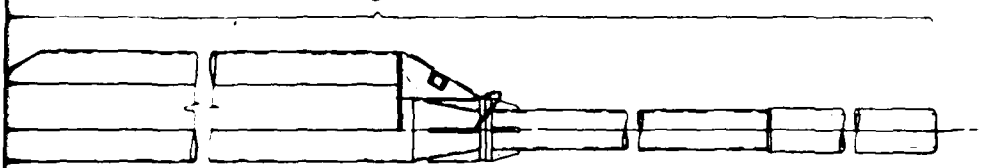
E - 001-A001 2 OF 2

ALTERATION APPROVAL

- 5" DRILL PIPE
LIGHT WEIGHT DRILL COLLAR APPROX 2,000#
(3) DRILL COLLARS 11,500#
BUMPER SUB 18,000# (2 TO 5 REQ'D)
(3) DRILL COLLARS 11,500#

LIST OF MATERIALS

RE-ENTRY SUB W/STINGER
67 FT - 7 3/16 INCHES
14,000 # APPROX



REV		DESCRIPTION	DATE
2		DELETED HEAVY WT D.P., ADDED LIGHT WT D.C., CHG BUMPER SUBS WAS 1 & CHG TOTAL WT	
1		REVISED PER BID PACKAGE	
0		INITIAL RELEASE	
A		PRELIMINARY RELEASE	

ALT. APPROVAL DATE | DESIGN APPROVAL DATE

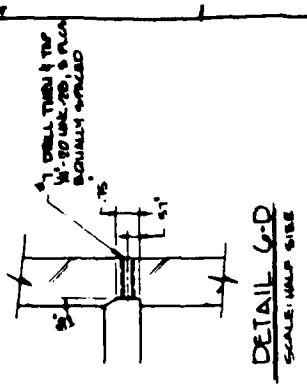
ALTERATION APPROVAL

GLOBAL MARINE DEVELOPMENT INC.

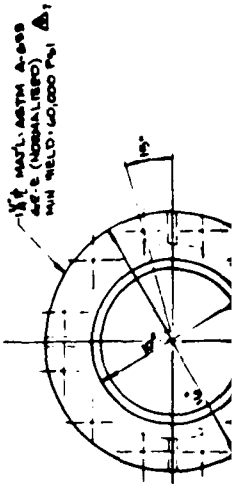
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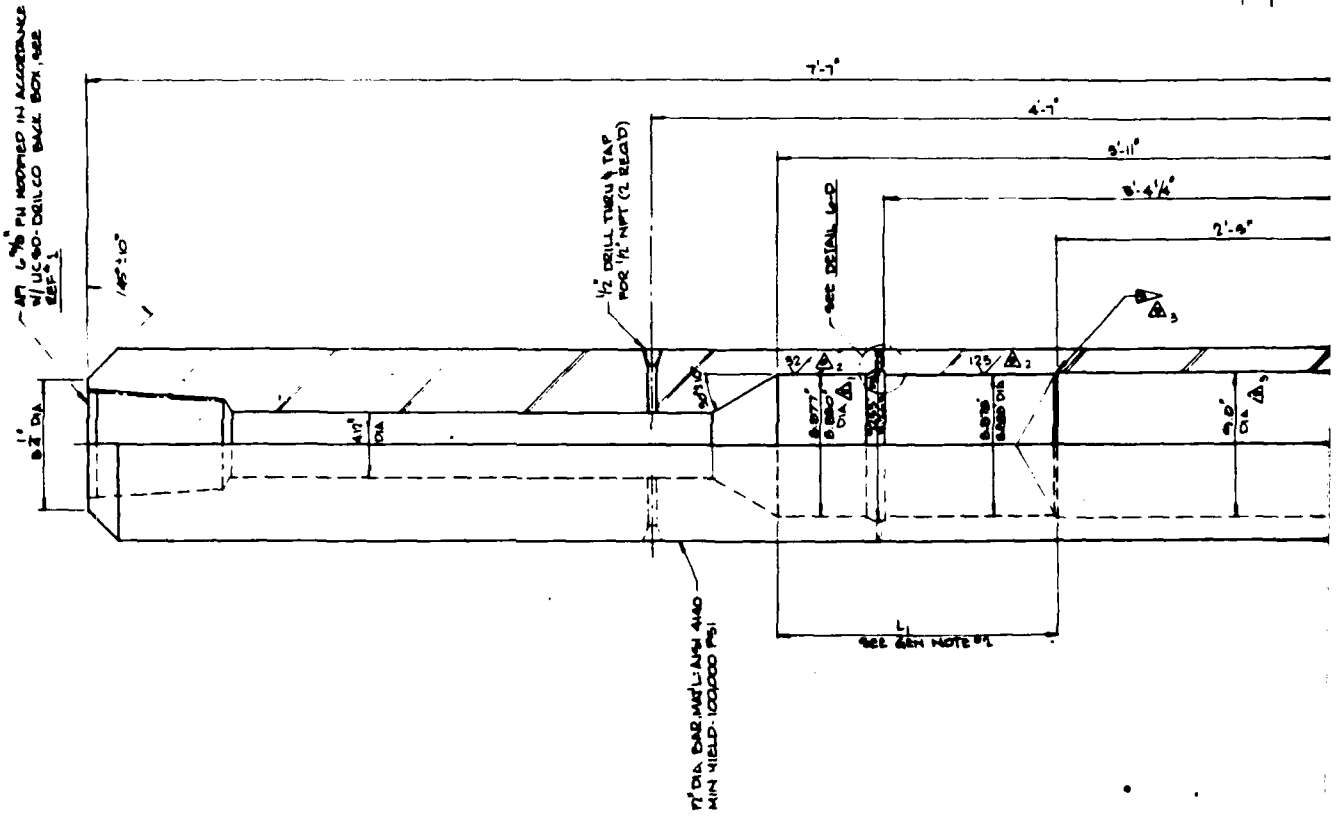
MARINE SEISMIC SYSTEM (MSS)
RE-ENTRY ASSEMBLY
CONTROL DRAWING

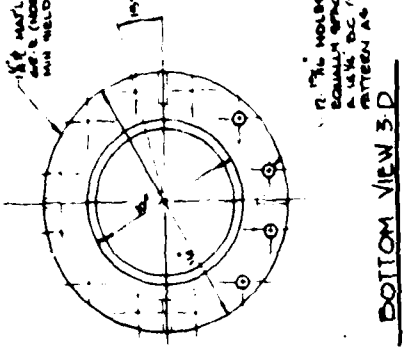
DR N.A. WARREN	7/10/80	NONE	
CHK'D	7/11/80		
ENGR	7/11/80		
APPR	7/11/80		
PROJ ENGR	7/11/80		
		001	E-001 A002
		110900	1 OF 2

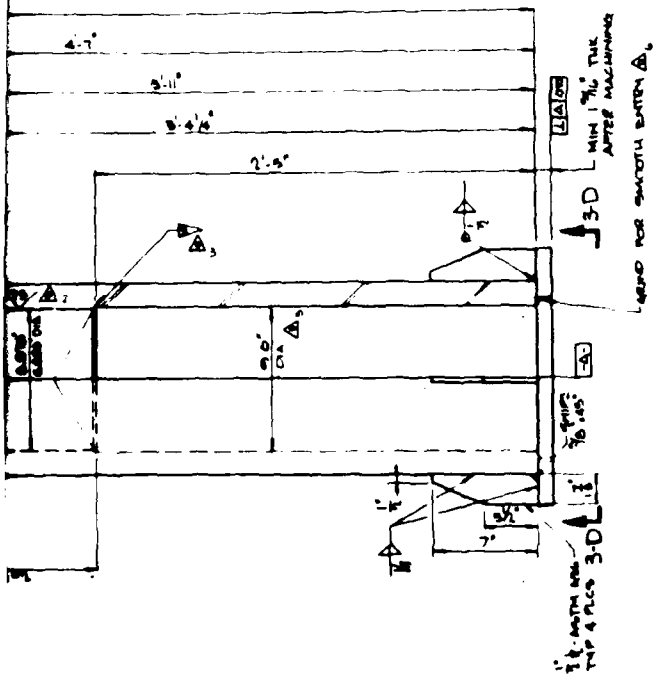


DETAIL 6-D
SCALE: WELD SIZE









LIST OF MATERIALS

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL MACHINE SURFACES TO BE 250
2. ALL INTERNAL DIAMETERS TO BE CONCENTRIC TO TIR .030, ONLY BORE LENGTH L1
3. BREAK ALL MACHINE CORNERS AND RADII TO 0.01" MIN
4. MACHINE TOLERANCES TO BE .X ± .1, .XX ± .05, .XXX ± .010
5. TRANSITION STEP IS TO BE SMOOTH TO AVOID ROLLING OUT O-RING IN HYDRAULIC PLUG/SONAR ADAPTOR (REF DWG #2)
6. ALL WELDS TO BE IN ACCORDANCE WITH AWS DL1 STRUCTURAL WELD CODE - STEEL

REFERENCE DRAWINGS:

1. C-0455 — UNIV. OF CALIF DEEP SEA DRILLING PROJECT 6 5/8" FULL HOLE MODIFIED BIT (DRILCO BORE-BACK BIT RELIEF)
2. D-001-A000 — MARINE SEISMIC SYSTEM (MSS) HYDRAULIC PLUG/SONAR ADAPTOR DETAILS

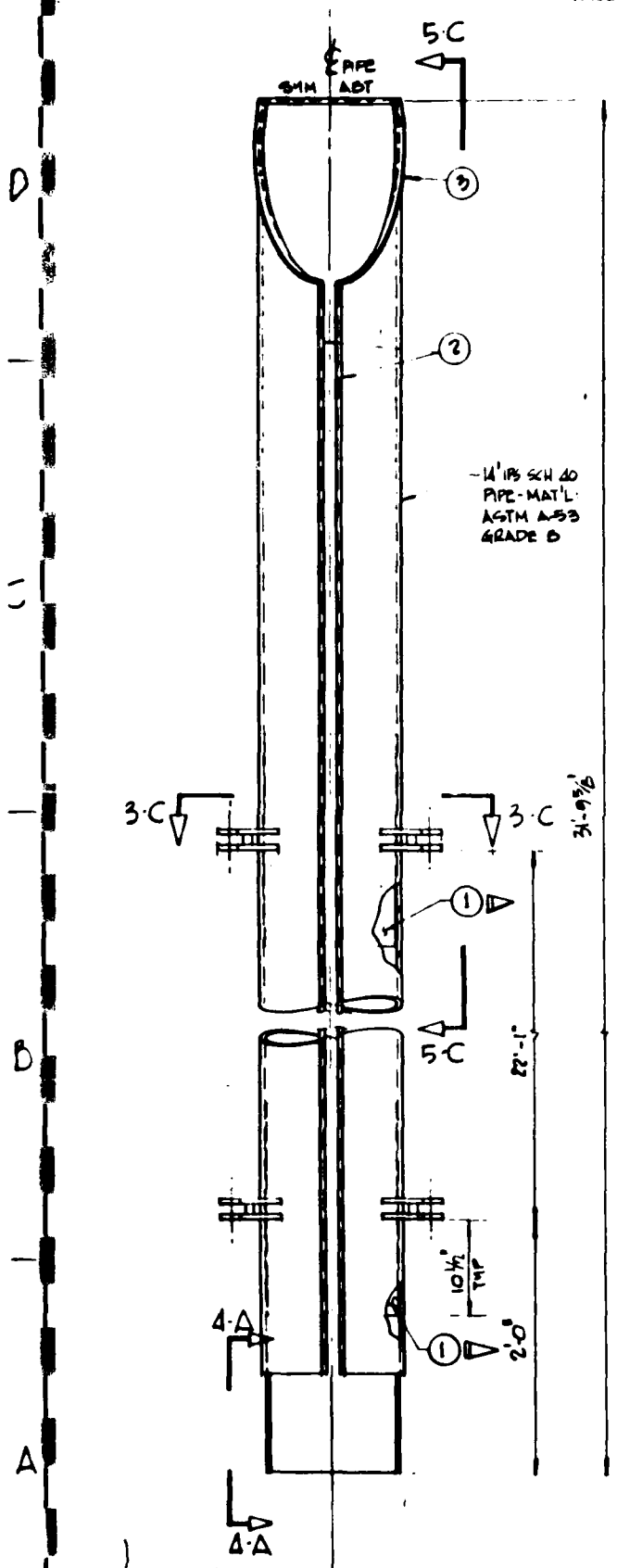
REV		
7	CHANGED FLANGE MATL VIEW B-D	
6	ADDED GRIND CALLOUT @ENTRY	001 10300
5	CHANGED DIM VIEW A-A? DIA	
4	CHANGED SURFACE REQUIREMENT IN GEN. NOTE #1 WAS ✓	
3	ADDED NOTE ▷ NOTE 6 REF #2	
2	ADDED SURFACE REQUIREMENT	
1	ADDED DIM	
D	CLARIFY L/M - OPEN UP TOL	
A	RELEASE FOR BID	

GLOBAL MARINE DEVELOPMENT INC.

[redacted]

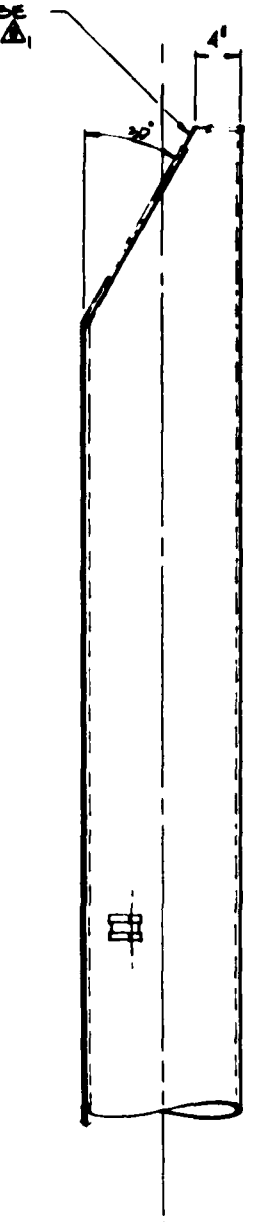
MARINE SEISMIC SYSTEM (MSS)
SHIP CARRIAGE CONTROL SUB
DETAILS AND ASSEMBLY

D-001-A000 | 10300 | E | 1 | 10



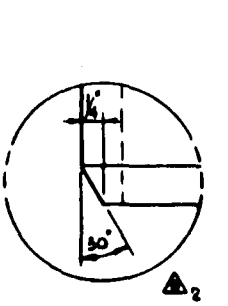
ELEVATION 6·A

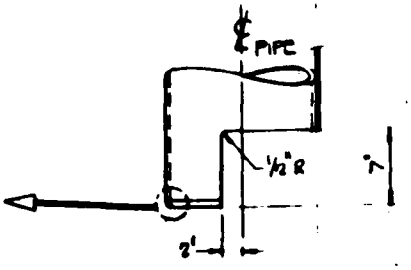
SCALE: 1½"=1'-0"



ELEVATION 5·C

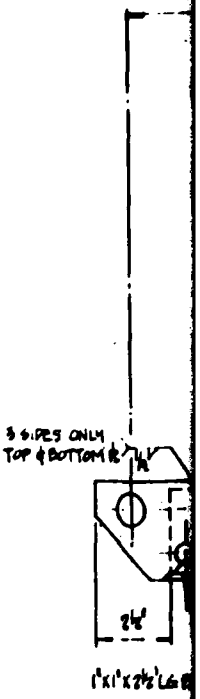
SCALE: 1½"=1'-0"





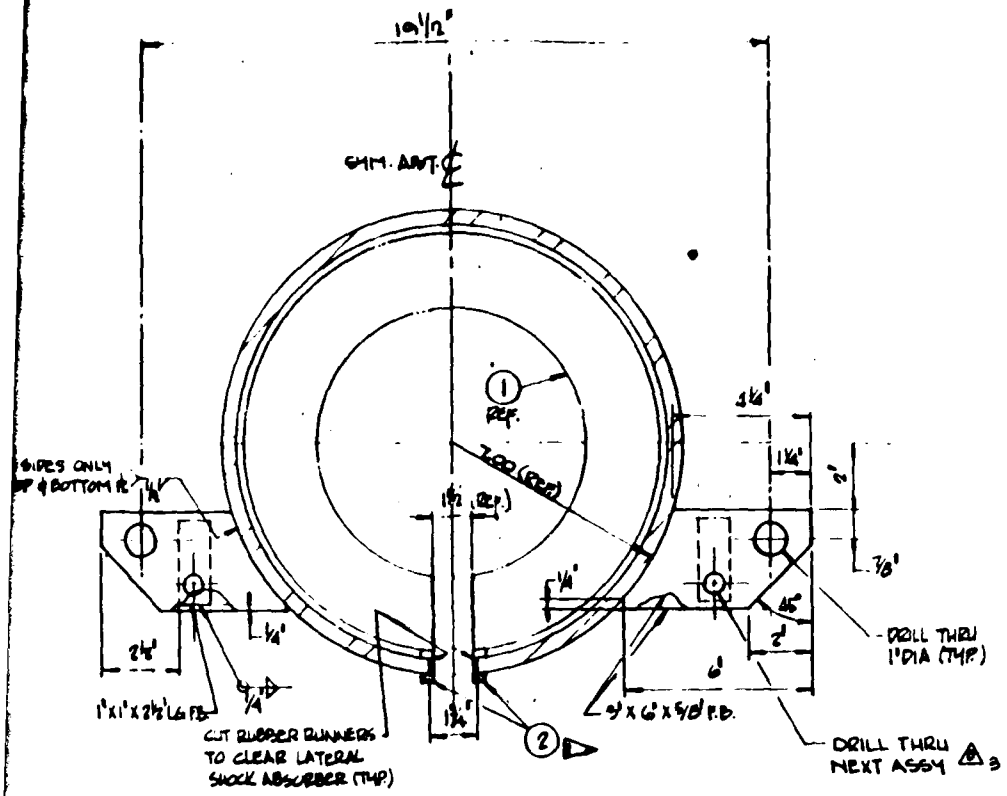
ELEVATION 4·A

SCALE: 1½"=1'-0"



LIST OF MATERIALS

ITEM	QTY	DESCRIPTION	MATERIAL SEE SPEC REQ
1	2	LATERAL SHOCK ABSORBER	REF 1
2	2	'RUBBER CRAFT' CAT # 1410 70 DUROMETER	NATURAL RUB W/ CHEMICAL CHANGE (HUMIDITY & HEAT RESISTANCE) AS REQ
3	1	'RUBBER CRAFT' CAT # 1410 70 DUROMETER	



SECTION 3-C

SCALE: 3/8"-0"-1"

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. TO BOND: USE WATER RESISTANT ADHESIVE, PER MANUFACTURERS RECOMMENDATION.
2. PAINT EXTERIOR IN ACCORDANCE WITH GMDI SPEC. 001-002.
3. ALL PLATES & SHAPES TO BE ASTM A36.
4. BREAK ALL SHARP EDGES & REMOVE ALL BURRS.

REFERENCES

1. C-001-A006 MARINE SEISMIC SYSTEM (MSS) LATERAL SHOCK ABSORBER RNG DETAIL

NO	DATE	BY	DESCRIPTION	ECN AUTH	APPD
1	11-4-80	NW	CHANGED MATERIAL CALLOUT FOR ITEMS 2 & 3 IN L/M WAS NATURAL RUB	006-230000	
0	10/20/80	NW	5. ADDED NOTE #4 4. CHANGE NOTE #2 TO EXTERIOR ONLY 8 ADDED SHEAR HOLE IN SEC. 3-C 2 BEVELED BOTTOM OF TUBE ELEV. 4-A 1 ADDED CALL OUT TO MAKE ℄ W/ ℄ TUBE IN ELEV. 5-C	001-210300	RW
B	7/25/80	NW	CLARIFY L/M - OPEN UP TOL.	001-210300	
A	9/25/80	MM	RELEASE FOR BID	001-210300	

ALTERATIONS

C 001 A006

NEXT ASSEMBLY ALTERATIONS

DATE
LOS ANGELES
NEWPORT BEACH
HOUSTON
PURCHASING
CONSTRUCTION
ENGINEERING
LEGAL
ABS

	APPROVED	CHANGES OR REVISIONS	ALT NO.	LETTER DATE	FILE REF NO.
ABS					
MMS					

TOTAL NET WGT (NAT'L)
TOTAL NET WGT (BOND)
TOTAL NET WEIGHT

GLOBAL MARINE DEVELOPMENT INC.
Newport Beach Calif

[redacted]

MARINE SEISMIC SYSTEM (MSS)

BIP CARRIAGE ASSEMBLY AND DETAILS

DRAFT [redacted]	9-9-80	SCALE: AS NOTED
ENGR [redacted]	[redacted]	TOLS UNLESS OTHERWISE NOTED: FRACTION ± 1/64" ANGULAR ± 1° DECIMALS ± .1 .01 .001 INTERPRET TOLS PER ANSI Y14.5
CHK [redacted]	[redacted]	
APPD [redacted]	[redacted]	ECN AUTH 001 210300
REL [redacted]	[redacted]	CODE IDENT D

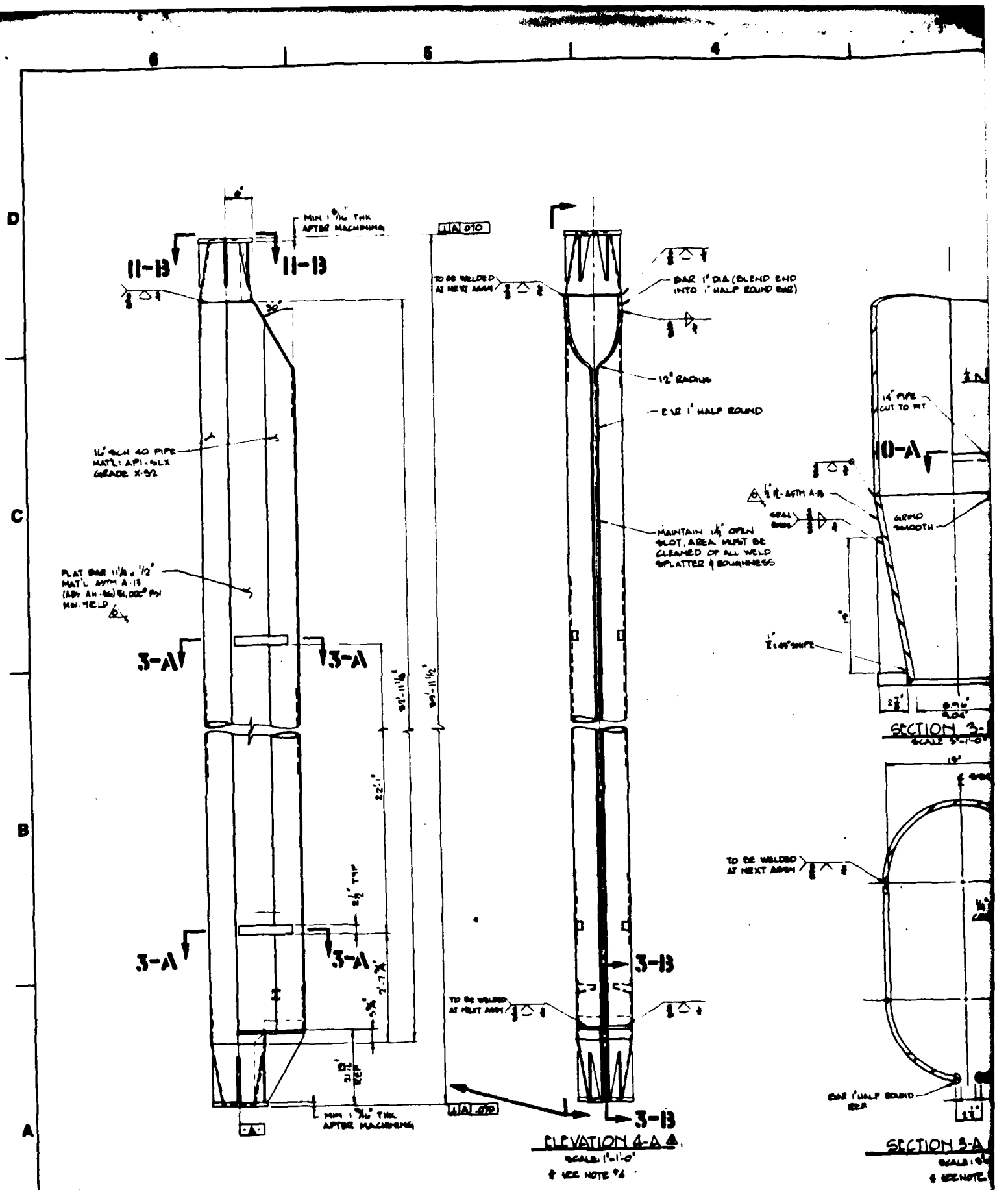
DWG NO. D 001 A004 SHT 1 OF 1 REV 1

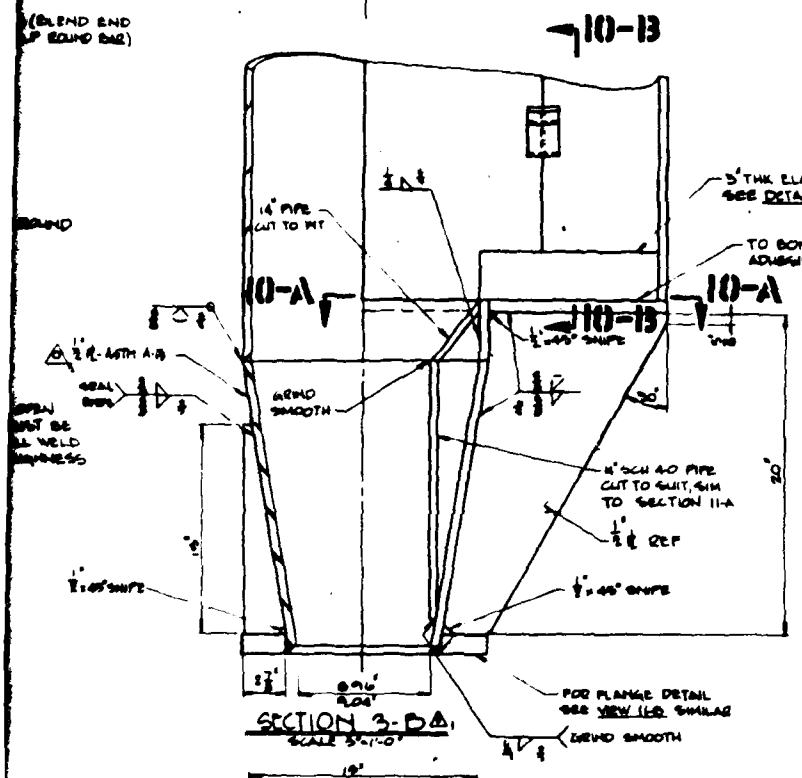
PIPE

1 1/2" R

SECTION 4-A

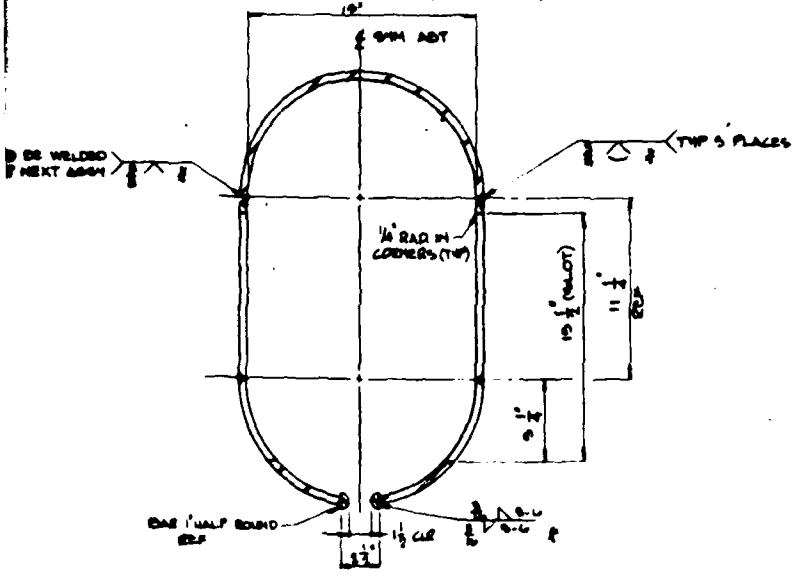
SCALE: 1 1/4"-1'-0"


MIN 1 9/16" THK AFTER MACHINING
11-13
11-13
30°
11" SCH 40 PIPE
MATL: API-5LX
GRADE X-52
PLAT BAR 11/8 x 1/2"
MAT'L ASTM A-13
(ABS AH-36) 51,000# PSI
MIN. YIELD
3-A
3-A
3-A
3-A
MIN 1 9/16" THK AFTER MACHINING
A
1/A 010
TO BE WELDED AT NEXT ASSY
BAR 1" DIA (BLEND END INTO 1" HALF ROUND BAR)
12" RADIUS
1" HALF ROUND
MAINTAIN 1/8" OPEN SLOT, AREA MUST BE CLEANED OF ALL WELD SPLATTER & ROUGHNESS
1/A 010
3-B
TO BE WELDED AT NEXT ASSY
3-B
ELEVATION 4-A
SCALE: 1"=1'-0"
& SEE NOTE 9
14" PIPE CUT TO FIT
10-A
GRIND SMOOTH
1" R. SHIPE
SECTION 3-
SCALE 3"=1'-0"
TO BE WELDED AT NEXT ASSY
BAR 1" HALF ROUND
SECTION 3-A
SCALE: 3
& SEE NOTE



SECTION 3-D

SCALE 3/4"=1'-0"



SECTION 3-A (ROTATED 90°)

SCALE: 6"=1'-0"

SEE NOTE #4

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL WELDING TO BE IN ACCORDANCE WITH AWS D1.1 STRUCTURAL WELDING CODE - STEEL
2. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS
3. ALL MACHINE SURFACES TO BE 125
4. ALL WELDS THIS ASSEMBLY TO USE E 7018 ELECTRODE EXCEPT AT END FLANGES (A-655) ARE TO BE WELDED WITH E 8018 ELECTRODE AND PRE HEAT @ 175°F

LIST OF MATERIALS				
ITEM	QTY			

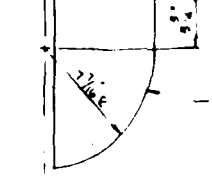
1			CHANGED RUBBER CALLOUT IN DETAIL 10-D WAS NATURAL		
O			4 REVISED MATL CALLOUT & ADDED NOTE #5 4 CHANGED DIM 17⅜" TO 17 3/16" SEC 11-A 3 ADDED BEVEL EDGE TO 14" PIPE IN SEC 11-A 2 ADDED 14" PIPE IN SEC 10-A 1 CHANGED DET B-B TO SEC B-B		
B			CLARIFY L/M - OPEN UP TOL.		
A			RELEASE FOR BID		

GLOBAL MARINE DEVELOPMENT INC.

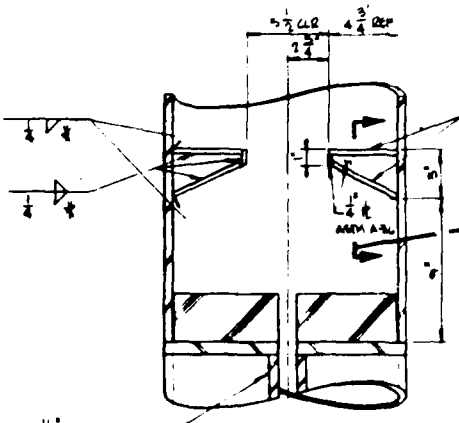
MARINE SEISMIC SYSTEM (MSS)

BIF CARRIAGE HOUSING ASSEMBLY AND DETAILS

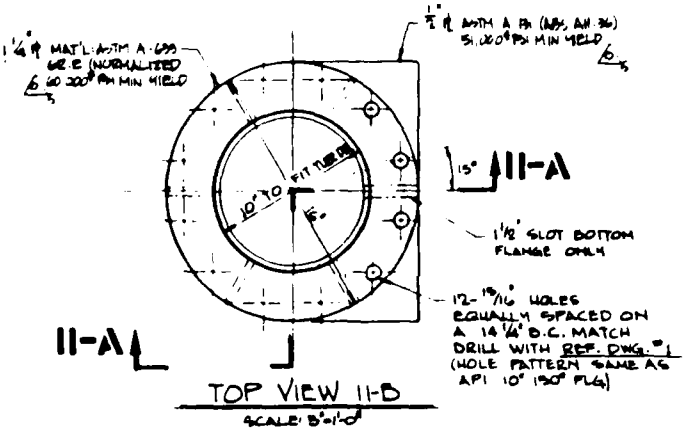
E 001 A005



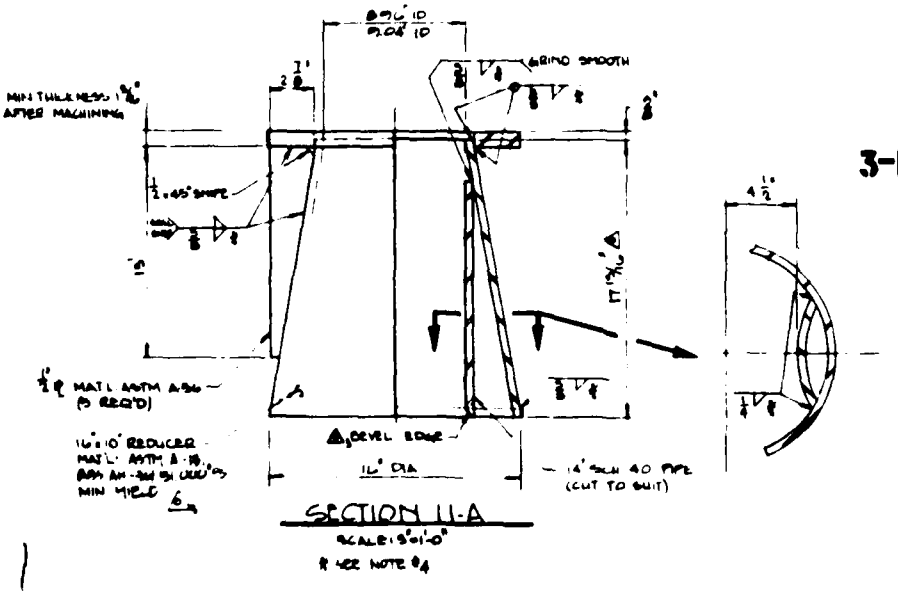
DETAIL 10-D
SCALE: 3"=1'-0"



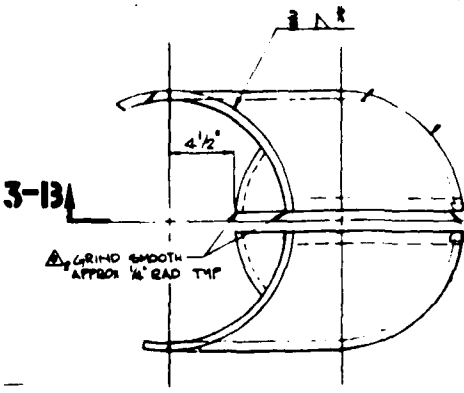
SECTION 10-B
SCALE: 3"=1'-0"
* SEE NOTE #4



TOP VIEW 11-D
SCALE: 3"=1'-0"

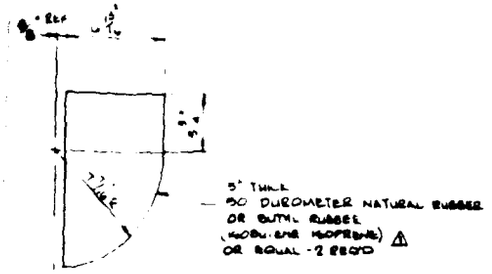


SECTION 11-A
SCALE: 3"=1'-0"
* SEE NOTE #4

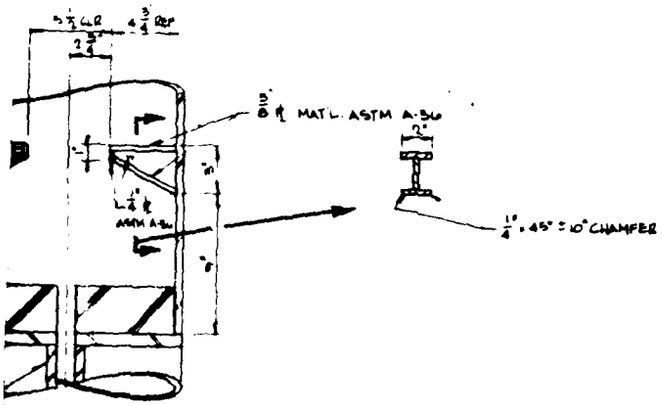


SECTION 10-A
SCALE: 3"=1'-0"
* SEE NOTE #4

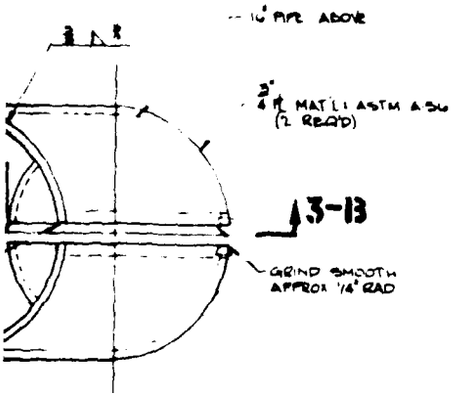
LIST OF MATERIALS



DETAIL 10-D
SCALE: 3"=1'-0"



SECTION 10-B
SCALE: 3"=1'-0"
SEE NOTE #4



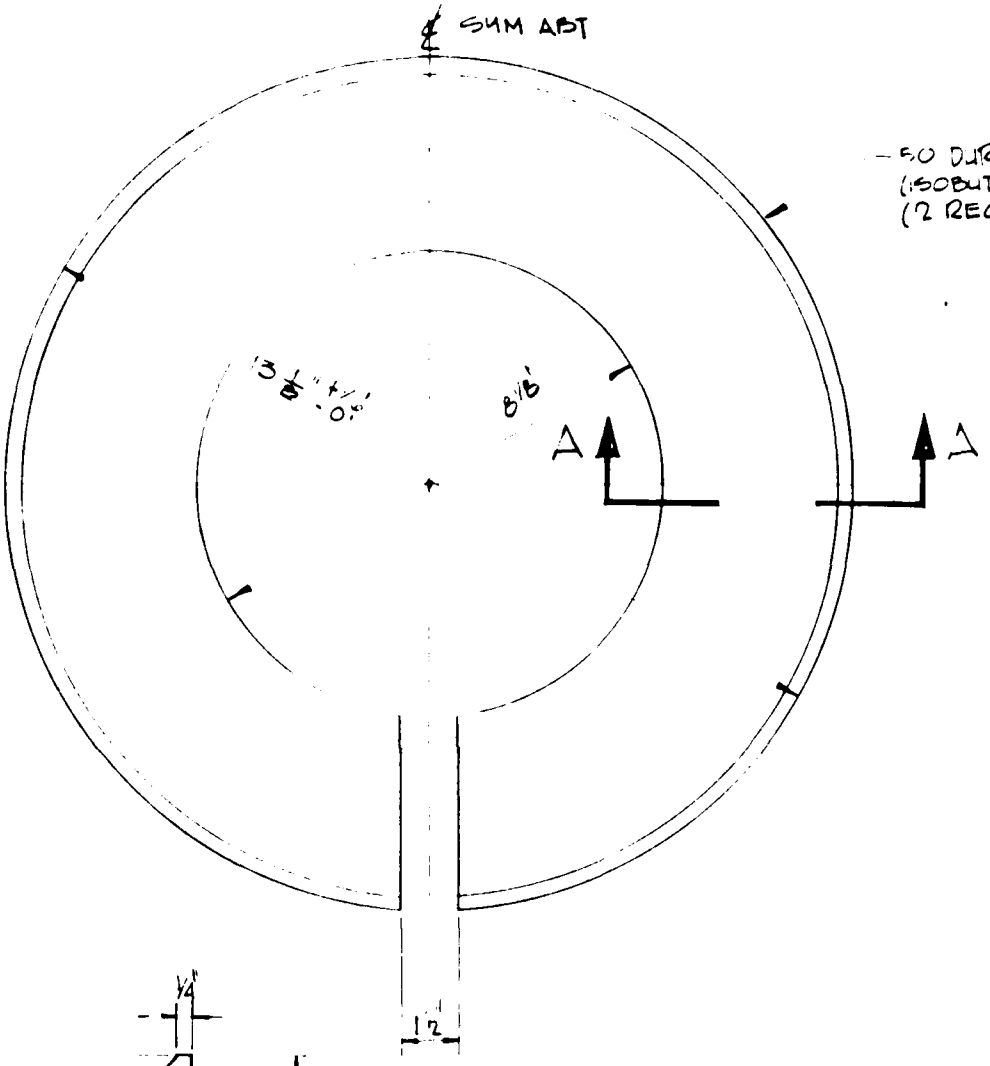
SECTION 10-A
SCALE: 3"=1'-0"
SEE NOTE #4

GLOBAL MARINE DEVELOPMENT INC

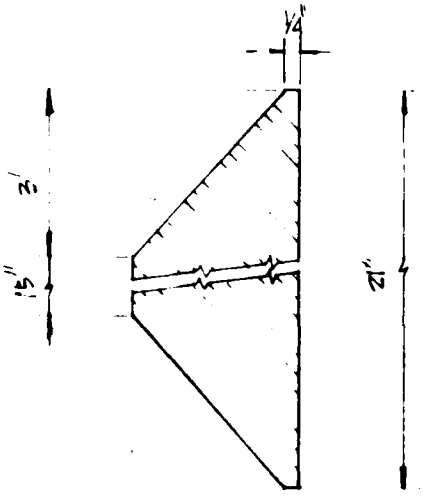
MARINE SEISMIC SYSTEM (MSS)

DIP CARRIAGE HOUSING ASSEMBLY AND DETAILS

E-001 • A005 | 1



– 50 DUROMETER NATURAL
(ISOBUTENE ISOPRENE) O
(2 REQ'D PER NEXT AS



1 SECTION A-A

D-001-A

NO REQ'D	NEXT ABS
	ALTERA
	DATE
	LOS ANGELES
	NEWPORT BEA
	HOUSTON
	PURCHASING
	CONSTRUCTI
	ENGINEERIN
	USCG
	ABS

	APPROVED	EXAMINED OR REVIEWED	ALT NO	LETTER DATE	FILE REF NO
ABS					
USCG					

TOTAL NET WGT MAT'L
TOTAL NET WGT EQUIP
TOTAL NET WEIGHT

LIST OF MATERIALS

OWNER FURN	ITEM	QTY	DESCRIPTION	MATERIAL OR DWG NO

50 DUROMETER NATURAL RUBBER OR BUTYL RUBBER
(ISOBUTENE ISOPRENE) OR EQUAL
(2 REQ'D PER NEXT ASSY)

A

NO	DATE	BY	DESCRIPTION	JOB AUTH	APPR
1	11-4-80	NW	CHANGED MAT'L CALLOUT WAS NATURAL RUB	006-323000	
0	10/10/80	NW	RELEASE FOR CONSTRUCTION	001-210300	
B	9/2/80	NW	CLARIFY L/M - OPEN UP TOL.	001-210300	
A	8/11/80	NW	RELEASE FOR BID	001-210300	

ALTERATIONS

D 001 A004

NO REQ'D

NEXT ASSEMBLY

ALTERATION

DATE

LOS ANGELES

NEWPORT BEACH

HOUSTON

PURCHASING

CONSTRUCTION

ENGINEERING

USCG

ABS

LETTER DATE | FILE REF NO

TOTAL NET WGT MAT'L

TOTAL NET WGT EQUIP

TOTAL NET WEIGHT

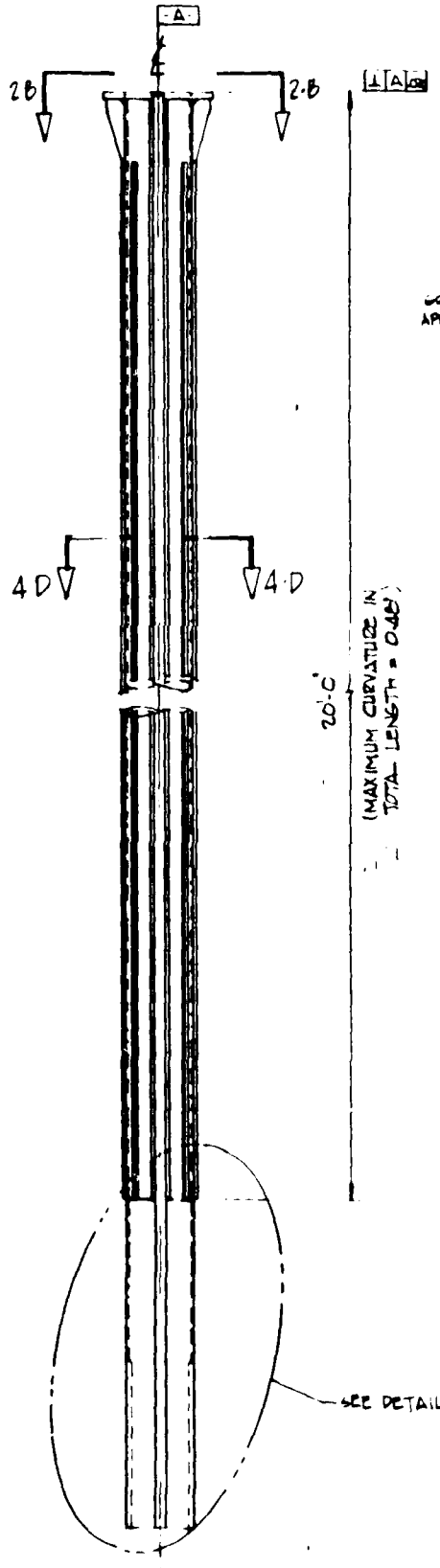
GLOBAL MARINE DEVELOPMENT INC.

Newport Beach, Calif

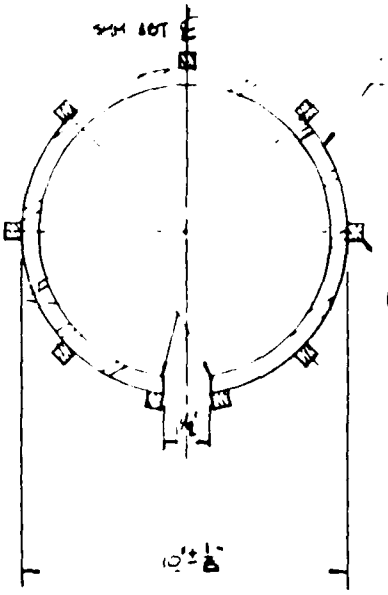
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MARINE SEISMIC SYSTEM (MSS)
LATERAL SHOCK ABSORBER RING DETAIL

Initial	Date	SCALE	TOLERANCE UNLESS OTHERWISE NOTED
DFT N.WAGNER	8/11/80	NONE	FRACTION ± 1/16" ANGULAR ± ½°
ENGR [illegible]	9/2/80		MILLIMETER ± 1 MM
CHK [illegible]	[illegible]		() DESIGNATES MILLIMETER DIMENSIONS
APPR [illegible]	[illegible]	JOB AUTH 001 210300	DWG NO C 001 A006
REL [illegible]	10/15/80		SHT 1 OF 1 ALT 1



ELEVATION 5-A
SCALE: 1"=1'-0"

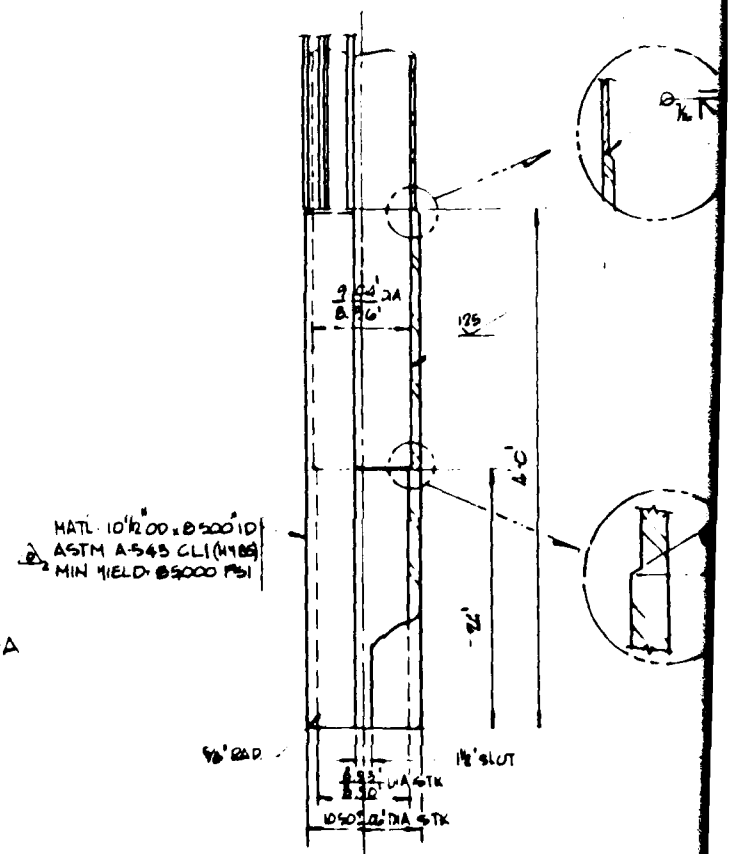


10' OD x 9.000 ID TUBING
MATL: A181 1020 STEEL (WI
MIN YIELD - 60,000 PSI
CUT OFF PIECE & TEST
FOR MATERIAL PROPER

GRIND SMOOTH
APPROX 1/4" RAD

(1) TO BOND USE WATER RESIS
ADHESIVE, PER MANUFACTURER
RECOMMENDATIONS

SECTION 4-D
SCALE: 3/16"=1'-0"



DETAIL 4-A
SCALE: 1/8"=1'-0"

3 2 1

D

C

B

A

9" OD x 9 GA W/ ID TUBING
MATL: A191 1020 STEEL (WDOM)
MIN YIELD - 60,000 PSI
CUT OFF PIECE & TEST Δ2
FOR MATERIAL PROPERTIES

MIN THK 1 3/16 AFTER MACHINING

E 70XX ROD 5/16 PREHEAT 175° 5/16 Δ2

E 80XX ROD 5/16 5/16 Δ2

Δ1 E 80XX ROD PREHEAT 175°

1/4" x 45° BVL DO NOT WELD

SMOOTH ENTRY

1/4" R MATL (3 REQD) ASTM A-36

LIST OF MATERIALS

ITEM	QTY	DESCRIPTION	MATERIAL OR SPEC NO
1	9	5/8 x 5/8 x 19.2" LG, 70 DURO METER	NATURAL RUBBER OR SINTH. RUBBER (MOBILITENE NEOPRENE) OR EQ

SECTION 2-D
SCALE: 3/8" = 0'-1"

SYM ABT

1/4" R MATL ASTM A 633 GR E (NORMALIZED) MIN YIELD - 60,000 PSI

E 80XX LOW HYDROGEN ELECTRODE PREHEAT 300°F Δ2

2-D

16" OD

TO FIT TUBING

GRIND SMOOTH APPROX 1/8" RAD

12 - 13/16" DIA HOLES EQUALLY SPACED ON 14 1/4" BC TYP (REF) 30° CL CLASS 150 SF STEEL FLG

15°

GRIND SMOOTH APPROX 1/8" RAD

SYM ABT

TOP VIEW 2-B
SCALE: 1/2" = 1"

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1 ALL WELDING TO BE IN ACCORDANCE WITH AWS D1.1 STRUCTURAL WELD CODE-STEEL

2 BREAK ALL EDGES AND REMOVE ALL BURRS.

3 MACHINE EDGES AND CORNER .015 MIN RADIUS Δ1

5 PAINT IN ACCORDANCE WITH GMDI SPEC 001-002.

NO	DATE	BY	DESCRIPTION OF ALTERATIONS	JOB AUTH	APPR
1	11-4-80	NW	CHANGED MATERIAL CALLOUT FOR ITEM 1 IN L/M WAS NATURAL RUBBER	006-325000	
			2 CHANGED MAT'L & WELD NOTE CALLOUTS IN DET. 4-A, SEC 4-D, SEC. 2-D & TOP VIEW 2-B.		
D	[illegible]	NW	1 DELETED GEN. NOTE #4	001-210300	
B	9-7-80	NW	CLARIFY L/M - OPEN UP TOL.	001-210300	
A	7-17-80	NW	RELEASE FOR BID	001-210300	

E 001-A009

NEXT ASSEMBLY

ALTERATION

DATE

LOS ANGELES

NEWPORT BEACH

HOUSTON

PURCHASING

CONSTRUCTION

ENGINEERING

USCG

ABS

NO	REQ'D

USCG	APPROVED	DRAWING OR REVIEWED	ALT NO	LETTER DATE	FILE REF NO

TOTAL NET WGT MAT'L

TOTAL NET WGT BOLT

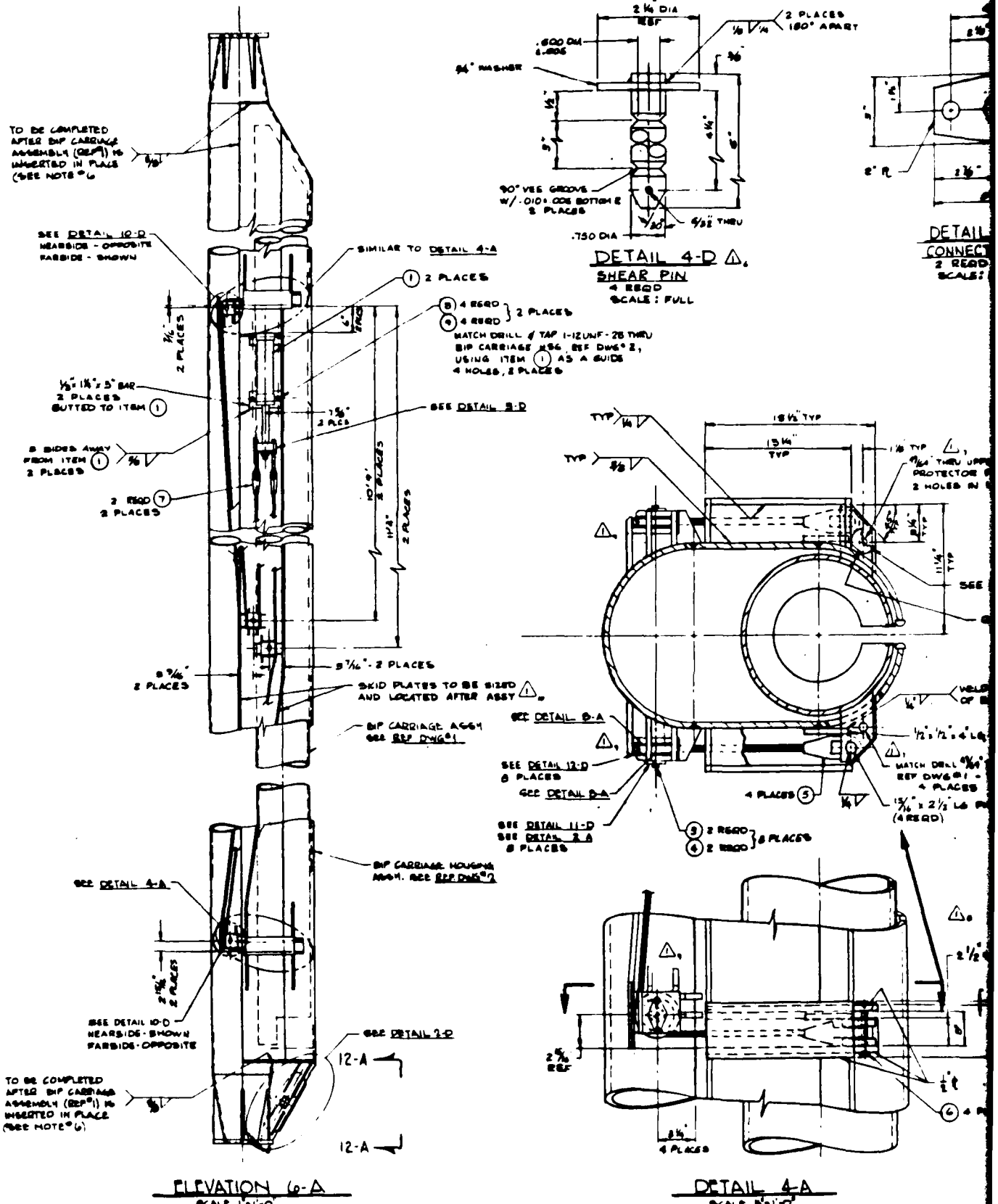
TOTAL NET WEIGHT

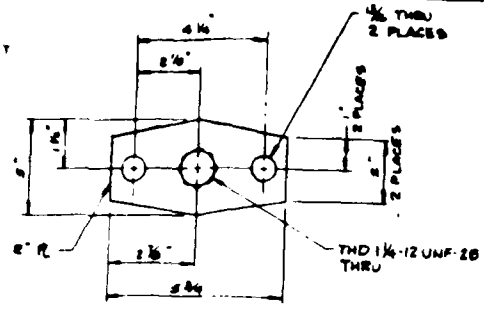
GLOBAL MARINE DEVELOPMENT INC.
Newport Beach Calif

[redacted]

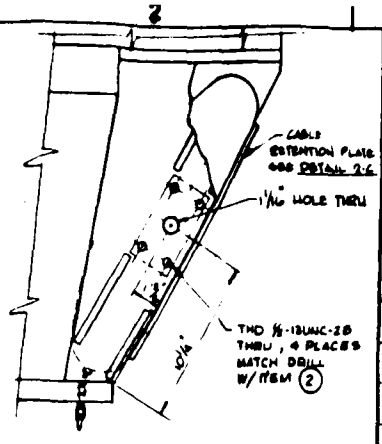
MARINE SEISMIC SYSTEM (MSS)
REENTRY TOOL STINGER ASSEMBLY AND DETAILS

DET MFG SETTINGS	DATE	SCALE	TOLERANCE UNLESS OTHERWISE NOTED
DRAWN PKA	7-8-80	1/2 NOTED	FRACTIONS 1/64" ANGULAR 1°
CHKD	9/4/80		DECIMALS TO 3 PLACES TO ± .005
APPR PKA	9/4/80	JOB AUTH UCA-210300	DRWG NO D *001 *A007
MGR [illegible]	10/15/80		SHT 1 OF 1
			ALT 1


TO BE COMPLETED AFTER BIP CARRIAGE ASSEMBLY (REF°1) IS INSERTED IN PLACE (SEE NOTE°6
SEE DETAIL 10-D NEARSIDE - OPPOSITE FARSIDE - SHOWN
SIMILAR TO DETAIL 4-A
2 PLACES
4 REQD
4 REQD
2 PLACES
MATCH DRILL & TAP 1-12UNF-2B THRU BIP CARRIAGE ASS'Y REF DWG°2, USING ITEM (1) AS A GUIDE 4 HOLES, 2 PLACES
1/2" x 1 1/4" x 5" BAR 2 PLACES BUTTED TO ITEM (1)
SEE DETAIL 9-D
B SIDES AWAY FROM ITEM (1) 2 PLACES
2 REQD 2 PLACES
SKID PLATES TO BE SIZED AND LOCATED AFTER ASSY
BIP CARRIAGE ASSY SEE REF DWG°1
BIP CARRIAGE HOUSING ASSY. SEE REF DWG°3
SEE DETAIL 4-A
SEE DETAIL 10-D NEARSIDE - SHOWN FARSIDE - OPPOSITE
SEE DETAIL 7-D
12-A
TO BE COMPLETED AFTER BIP CARRIAGE ASSEMBLY (REF°1) IS INSERTED IN PLACE (SEE NOTE°6)
2 1/4" DIA REF
2 PLACES 180° APART
.600 DIA
3/4" WASHER
90° VEE GROOVE W/ .010 CDS BOTTOM 2 PLACES
.750 DIA
DETAIL 4-D
SHEAR PIN
4 REQD
SCALE : FULL
SEE DETAIL 9-A
SEE DETAIL 12-D 8 PLACES
SEE DETAIL 8-A
SEE DETAIL 11-D
SEE DETAIL 2-A
8 PLACES
4 PLACES
2 REQD
2 REQD
8 PLACES
MATCH DRILL
REF DWG°1 - 4 PLACES
4 REQD
ELEVATION 6-A
SCALE 1"=1'-0"
DETAIL 4-A
SCALE 3"=1'-0"



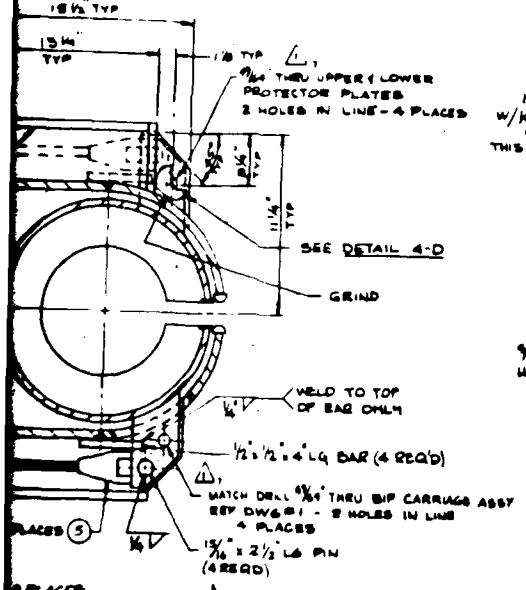
DETAIL 3-D
CONNECTOR PLATE
2 REQD
SCALE: HALF SIZE

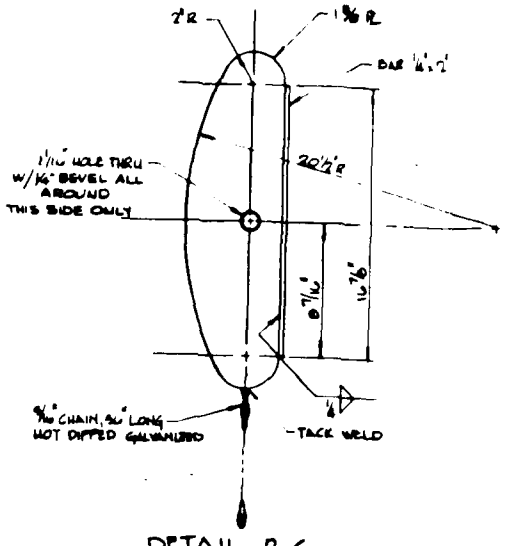


DETAIL 2-D
(HYDRAULIC CYLINDER REMOVED FOR CLARITY)
SCALE: 3/4"=1'-0"

LIST OF MATERIALS

	ITEM	QTY	DESCRIPTION	PART OR IDENT NO
	1	2	4" BORE, 12" STROKE SERIES "2H" HEAVY DUTY HYDRAULIC CYLINDER STYLE C (NFPA MX2) W/66 ROD & THREAD STYLE 42 ROD END 1 1/4-12 THREAD W/ANN NUT CUSHIONED BLIND END	PARKER HANNIFIN OR EQUAL
	2	1	2" BORE, 2" STROKE SERIES "2H" HEAVY DUTY HYDRAULIC CYLINDER STYLE J (NFPA MP1) W/66 ROD END STYLE 9	
	3	16	WASHER, LOCK - 1/4" I.D. x 1/16" THK	SS
	4	16	BOLT, HEX HD, 1/4-20 THD x 1/2" LONG	SS
	5	4	1/2" CLOSED SPLITTER SOCKET	
	6	4	1/8" COTTER PIN	
	7	4	BOLT, ELEVATOR SOCKET FOR 1/2" DIA WIRE ROPE 8" SHANK W/4" THD LENGTH	9/16797-5 BROWNE-TITCHENER CORP OR EQUAL
	8	8	WASHER, LOCK - 1" I.D. x 1/8 THK	SS
	9	8	BOLT, HEX HD, 1-12UNF -2A x 1 3/4" LG	SS





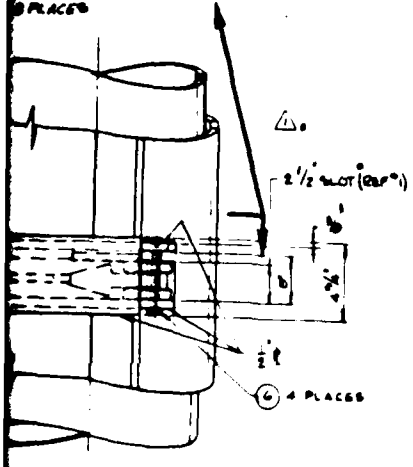
DETAIL 2-C
CABLE RETENTION PLATE
SCALE: 3"=1'-0"

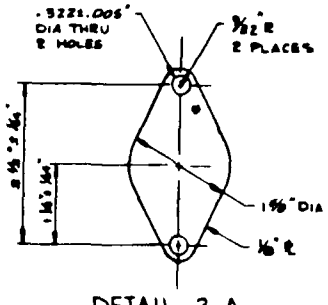
GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL MATERIAL TO BE ASTM A-36 OR EQUAL.
2. ALL WELDING TO BE IN ACCORDANCE WITH AWS D1.1 STRUCTURAL WELDING CODE - STEEL.
3. ALL MACHINE SURFACES TO BE 125/.
4. BREAK ALL SHARP EDGES & REMOVE ALL BURRS.
5. PAINT IN ACCORDANCE WITH GMDI SPEC 001-002.
6. ALL WELDS THIS ASSY SHALL USE E 7018 ELECTRODE.
7. GENERAL TOLERANCES ON DECIMAL DIMENSIONS:
 .X ± 0.1
 .XX ± 0.03
 .XXX ± 0.010

REFERENCE DRAWINGS:

1. D-001-A004 MARINE SEISMIC SYSTEM (M55) BIP CARRIAGE ASSEMBLY & DETAILS
2. E-001-A005 MARINE SEISMIC SYSTEM (M55) BIP CARRIAGE HOUSING ASSEMBLY AND DETAILS





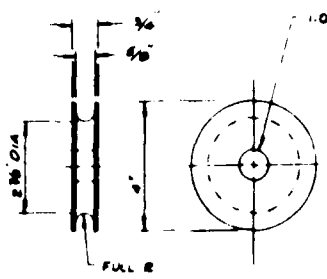
DETAIL 2-A
COVER
8 REQD
SCALE: FULL

ITEM	QTY	DESCRIPTION	DWG NO
11. ADDED S/N 7. 10. ADDED SKID PLATES. 9. REVISED PICTURE TO AGREE W/SHEAVE SUPPORT CHGS. 8. DELETED TUBE CALLOUT. 7. CHANGED CALLOUT FOR NEW PIN. 6 COMPLETELY REVISED PIN. 5. REVISED DIMENSIONS & TOL TO DECIMALS. 4. REVISED GUSSET & CHGD DIMS. 3. REVISED DIMENSIONS. 2. ADDED VIEW. 1. REVISED SHEAVE SUPT. GUSSETS			E-001-A006 REVISED
0		DWG COMPLETELY REVISED ADDED SHEET 2 RELEASED FOR CONSTRUCTION	E-001-210300
D		CLARIFY L/M - OPEN UP TOL	E-001-210300 SHT 1
A		RELEASE FOR BID	E-001-210300 SHT 1

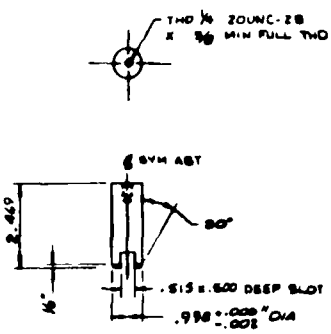
GLOBAL MARINE DEVELOPMENT INC.

MARINE SEISMIC SYSTEM (M55)
BIP CARRIAGE HOUSING
MAIN ASSEMBLY

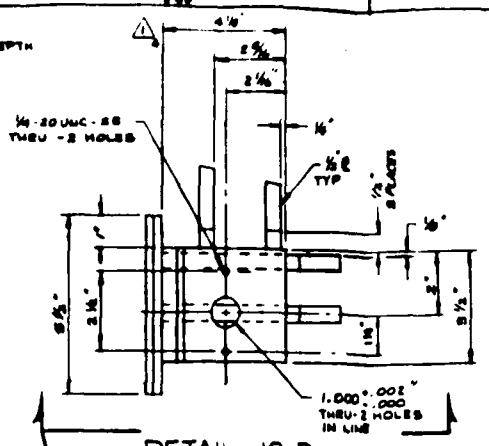
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	E-001-210300		



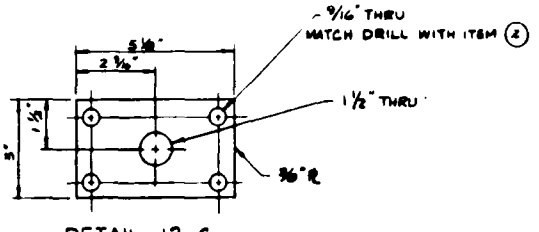
DETAIL 12-D
SHEAVE
6 REQD - MAT'L: TOBIN BRONZE PER SAE-H-35
SCALE: HALF SIZE



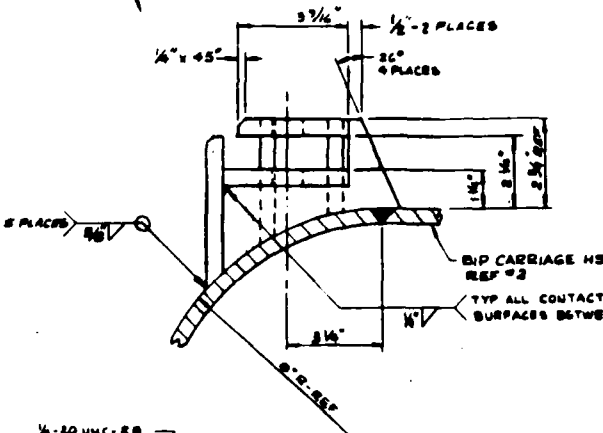
DETAIL 11-D
SHEAVE PIN
6 REQD - MAT'L: 5/16 CRES
SCALE: HALF SIZE

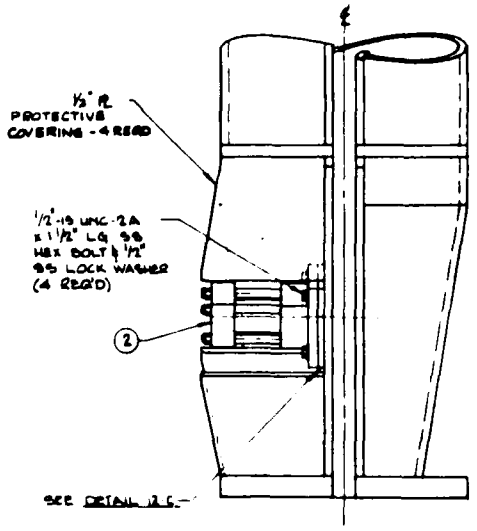


DETAIL 10-D
SHEAVE SUPPORT
2 REQD AS SHOWN
2 REQD OPPOSITE
SHEAVE AND PIN OMITTED FOR CLARITY
SCALE: HALF SIZE

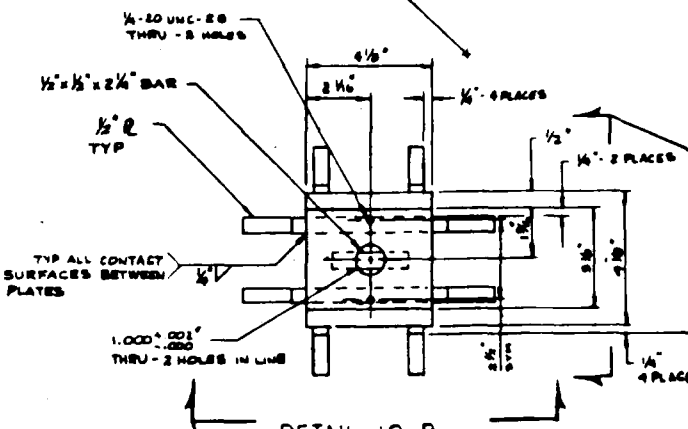


DETAIL 12-C
SPACER
SCALE: HALF SIZE

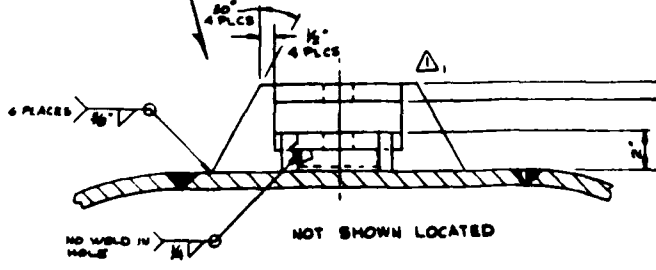




SECTION 12-A
SCALE: 3"=1'-0"



DETAIL 10-B
SHEAVE SUPPORT
4 REQD
2 ORIENTATED AS SHOWN
2 ROTATED 90°
SHEAVE, PIN & COVER OMITTED FOR CLARITY
SCALE: HALF SIZE

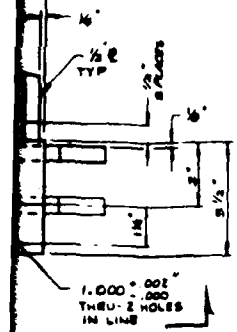


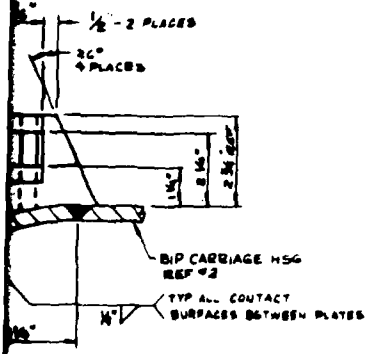
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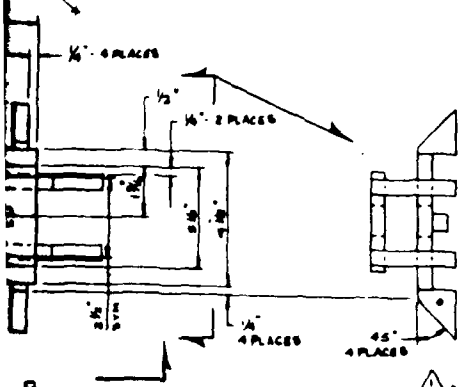
9 11 7

LIST OF MATERIALS

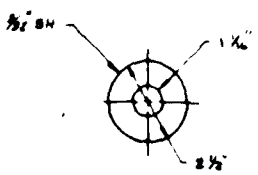
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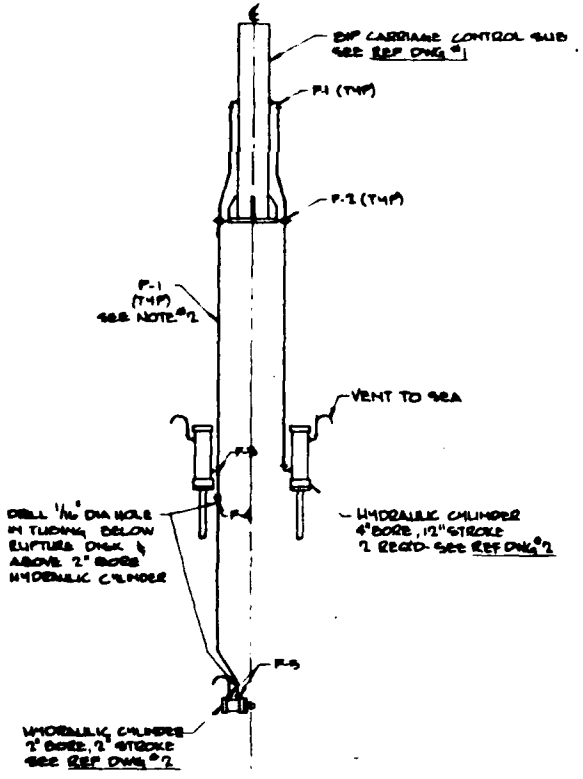


DETAIL B-A
THRUST WASHER
MATERIAL: ⅛ HARD BRASS
IS 8600
SCALE: HALF SIZE

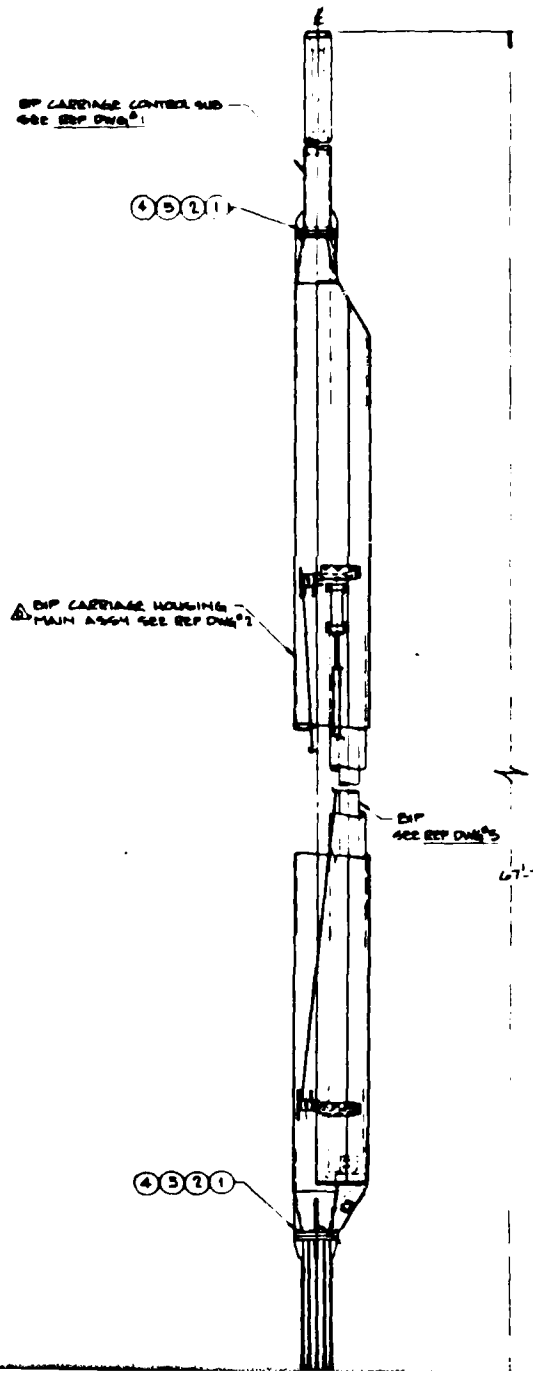
GLOBAL MARINE DEVELOPMENT Inc.

MARINE SEISMIC SYSTEM (MSS)
BIP CARRIAGE HOUSING
MAIN ASSEMBLY

E-001-A008



HYDRAULIC SCHEMATIC
NTS

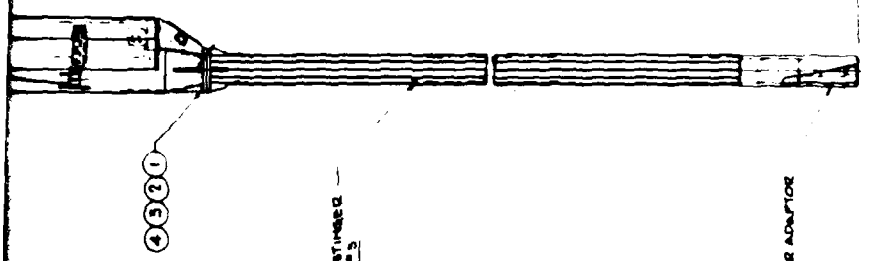


			LIST OF MATERIALS	
	1	24	3/8"-16 UNC 2A x 5 3/8" LG CARBOLOY SOCKET HEAD CAP SCREW	ASTM A574 TYPE 3
	2	24	3/8" FLAT WASHERS	
	3	24	3/8" LOCK WASHER	
	4	24	3/8"-16 UNC 2B CARBOLOY SOCKET HEAD NUT	ASTM A194 TYPE 3
	P-1	8	6-8-6BTS - MALE ELBOW	6-6
	P-2	2	8 BRTS UNION	
	P-3	1	8 BRTS MALE BRANCH TEE	
	P-4	1	1/4" RUPTURE DISC, SOLID DISC SET AT 3100 PSI	
	P-5	2	8-8-8BTS MALE CONNECTOR	
	P-6		1/2" O.D. SEAMLESS TUBING 6-8 TYPE 304 1/8 HARD	

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL TUBING FITTING ARE JIC 37 1/2° FLARE TYPE DESCRIPTION IS PER PARKER HANNIFIN CATALOG 4400 REV. SEPT 1968
2. HYDRAULIC PIPING RUN TO BE DETERMINED BY MANUFACTURER.

ELEVATION 2-C



REENTRY TOOL STINGER
SEE REF DWG # 3

HYDRAULIC FLUID/SONAR ADAPTOR
SEE REF DWG # 4

REFERENCE DRAWINGS:

1. E-001-A009	MARINE SEISMIC SYSTEM (MSS) DIP CARRIAGE CONTROL SUB DETAILS AND ASSEMBLY
2. E-001-A008	MARINE SEISMIC SYSTEM (MSS) DIP CARRIAGE HOUSING MAIN ASSEMBLY
3. D-001-A007	MARINE SEISMIC SYSTEM (MSS) REENTRY TOOL STINGER ASSEMBLY AND DETAILS
4. D-001-A010	MARINE SEISMIC SYSTEM (MSS) HYDRAULIC FLUID/SONAR ADAPTOR DETAILS

TELEDYNE GEOTECH DRAWINGS

5. 990-99100 DIP

HYDRAULIC SCHEMATIC
N.T.S.

HYDRAULIC CYLINDER
2" BORE, 2 STROKE
SEE REF DWG # 2

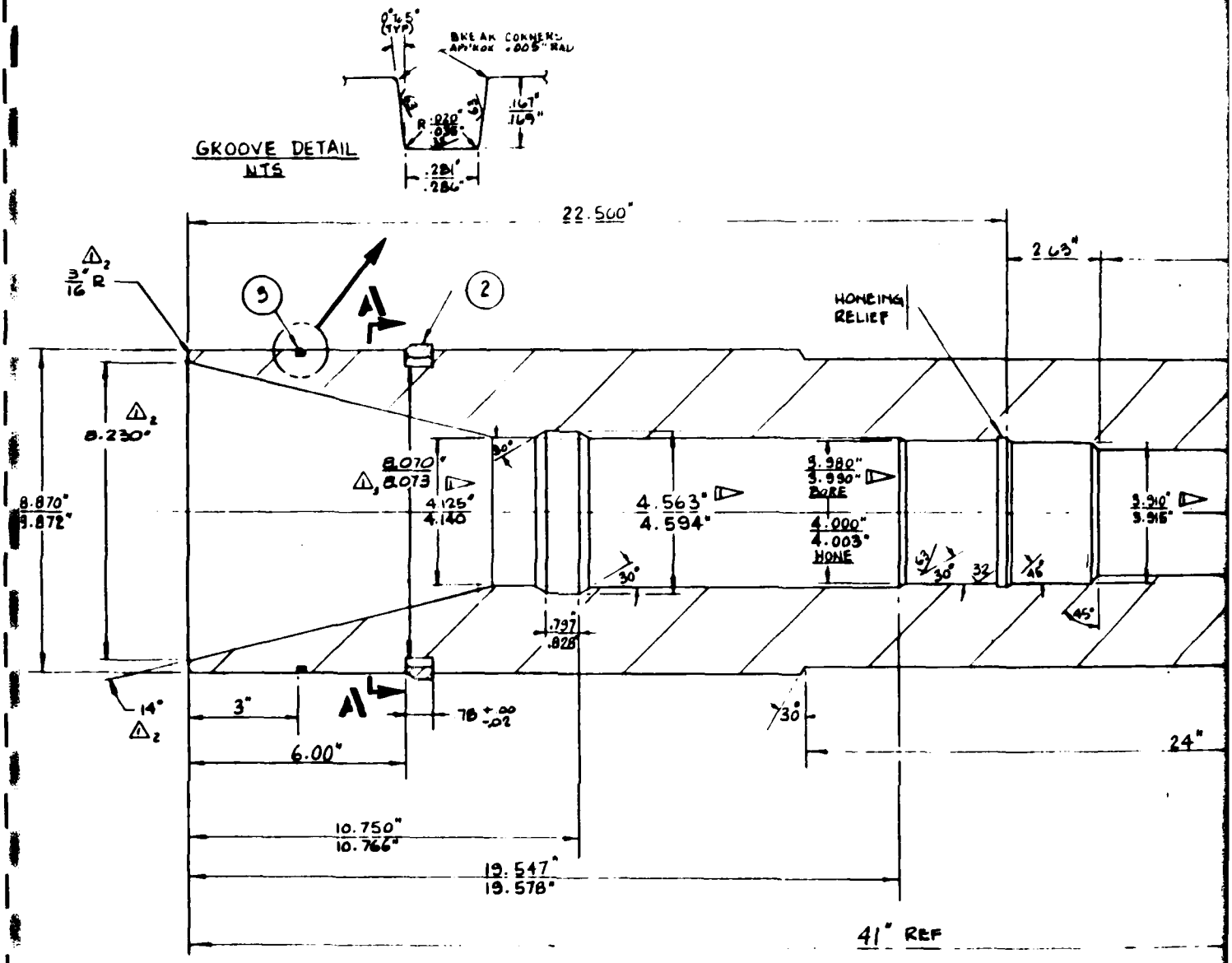
D	2	ADDED NOTE #2 REVISED ELEV 2-C PER REF DWG #2 CHANGES	001 2 10500
C		REDRAWN FOR CLARITY	001-A10500 2 10700
B		RELEASE FOR BID	

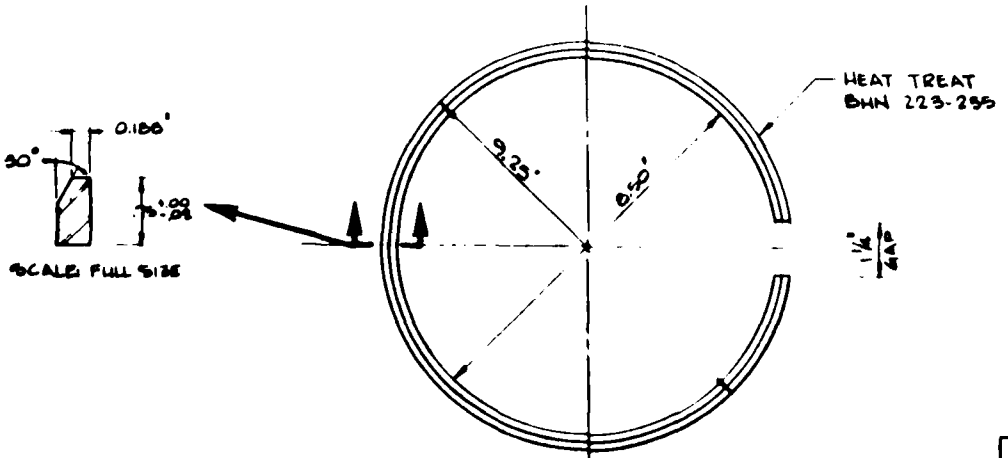
GLOBAL MARINE DEVELOPMENT INC.

[redacted]

MARINE SEISMIC SYSTEM (MSS)
DIP REENTRY TOOL
ASSEMBLY

DRN		1/2" = 1'-0"	
CHK			
APP			
	001 2 10700	E - 001 - A005	0





SECTION A-A

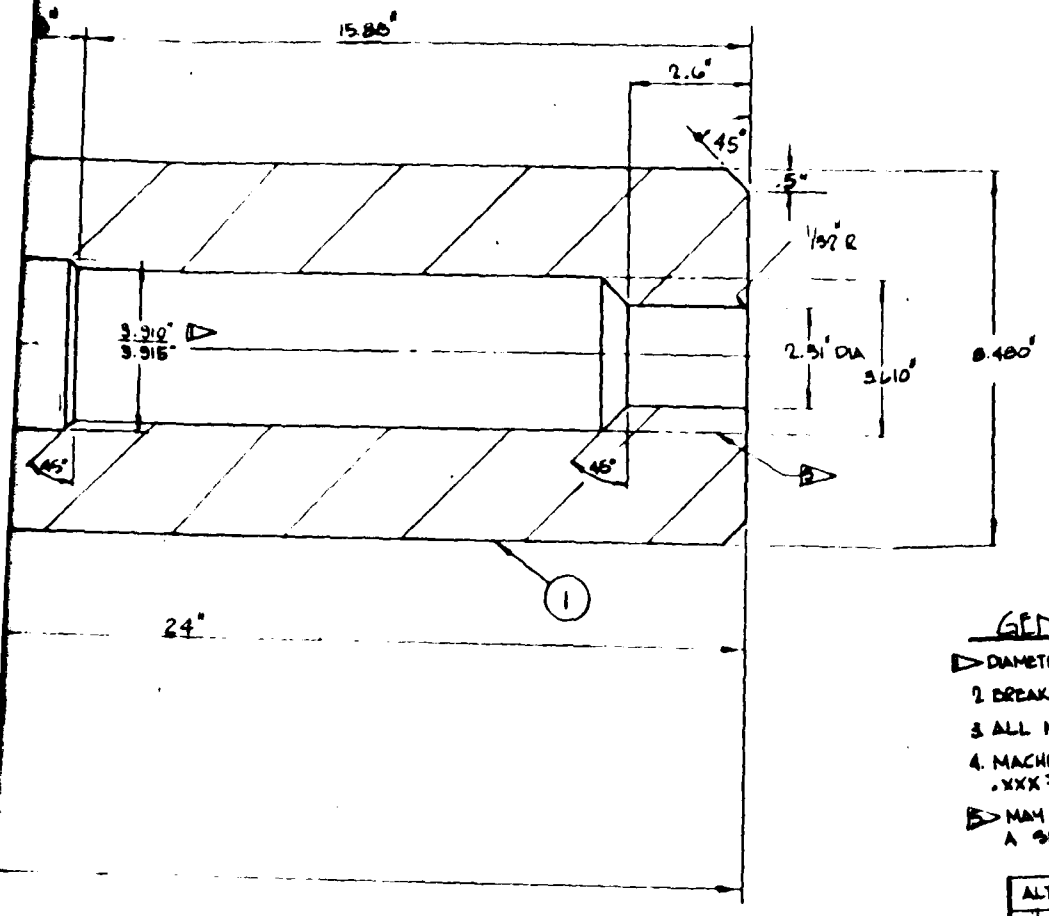
② SNAP RING

NO.	DATE	BY	DESCRIPTION
1			3. CHANGED: WAS 8.180
			2. ADDED: MLR, 14°, 8.23
			1. DELETED: 8 DIA, 6.80,
			4.160/4.176

ALTERATIONS

LIST OF MATERIALS

CHANGE SYMBOL	ITEM	QTY	DESCRIPTION	MATERIAL OR FIND NO
	1	1	H.P./S.A.	AISI 4140
	2	1	SNAP RING	
	3	1	O-RING PARKER-371 OR EQ 90 DUROMETER SHORE A HARDNESS	N RUBBER



GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ▷ DIAMETERS TO BE CONCENTRIC TO .030 TIR
2. BREAK ALL MACHINE CORNERS & RADII TO 0.01" MIN
3. ALL MACHINE SURFACES TO 125
4. MACHINE TOLERANCES TO BE .x ± .1, .xx ± .05, .xxx ± .010
5. ▷ MAY BE MADE WITH A PRESSED IN COLLAR AS A SEPARATE PART

ALTERATIONS CONTINUED BOTTOM OF SHEET

NO	DATE	BY	DESCRIPTION ALTERATIONS	JOB AUTH	APPR
C	9-11-80	NW	1. CHANGED SNAP RING DIM. 2. CHANGED GROOVE DIM. 3. DIM. CHANGE WAS [illegible] 4. DIM CHANGE WAS 2.75 5. DIM CHANGE WAS 3.69 6. DIM CHANGE WAS [illegible] 7. ADDED 90 DUROMETER HARDNESS O-RING	001-210500	
B	9-4-80	NW	CLARIFY L/M - OPEN UP TOL	001-210500	
A	7-18-80	AB	RELEASE FOR BID	001-210500	

GLOBAL MARINE DEVELOPMENT INC.
Newport Beach Calif

[redacted]

MARINE SEISMIC SYSTEM (MSS)
HYDRAULIC PLUG / SONAR ADAPTOR DETAILS

	NAME	DATE
DFT	B. BUCHANAN	9-11-80
DESN	B. BUCHANAN	9-11-80
CHK	[illegible]	[illegible]
APPD	[illegible]	[illegible]
REL	[illegible]	[illegible]

SCALE: HALF SIZE & NOTED
TOLERANCES UNLESS OTHERWISE NOTED: FRACTION ± 1/16" ANGULAR ± 1°; MILLIMETER ± 1 mm; .1 DESIGNATES MILLIMETER DRAWINGS
JOB AUTH: 001-210500
DWG NO: D °001°A010
SHT 1 OF 1
REV: A

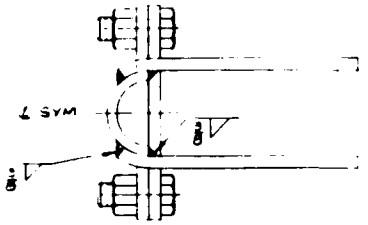
ADDED: WAS 8.120/8.125
ID: MLR, 90°, 8.250
ADDED: 8 DIA, 8.50, 15°, 80°, 8, 4.160/4.178

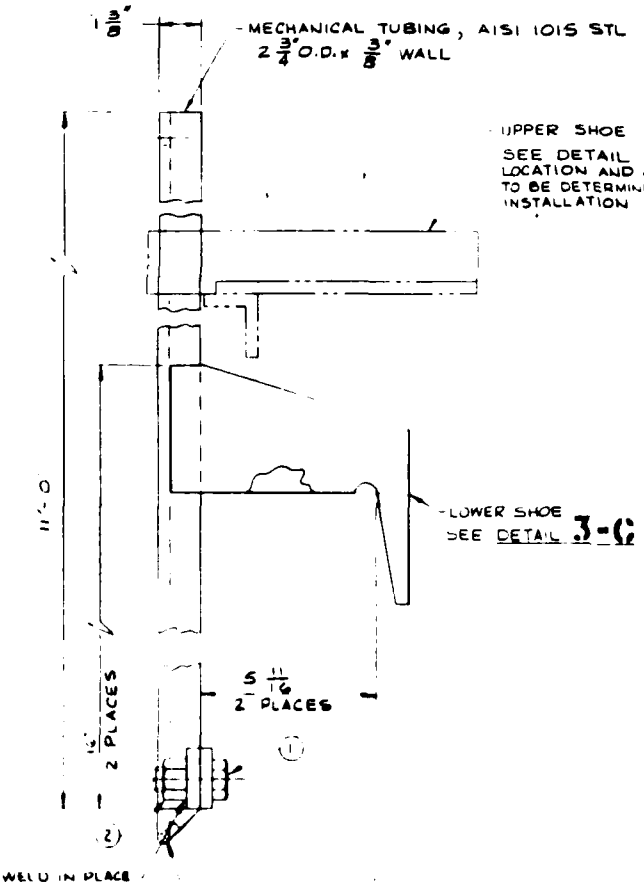
DESCRIPTION ALTERATIONS	JOB AUTH	APPR
	006-529000	

ASS USED ON	APPROVED	EXAMINED OR REVIEWED	ALT NO	LETTER DATE	FILE REF NO

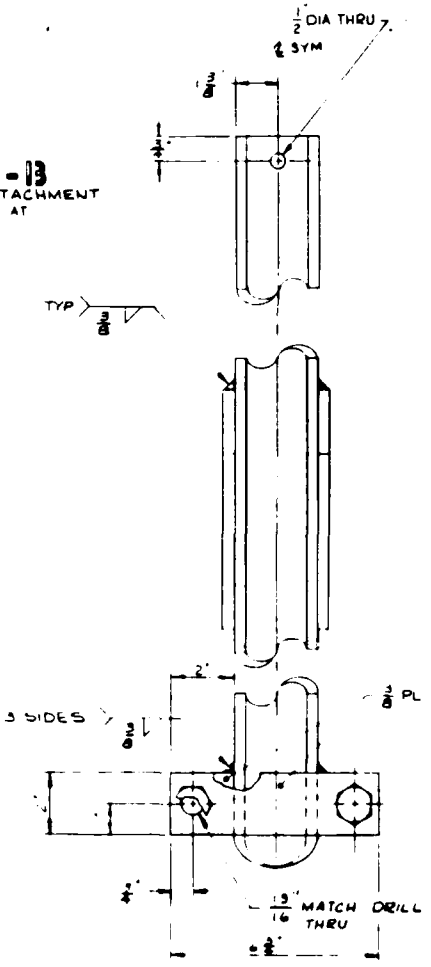
TOTAL NET WGT MAT'L
TOTAL NET WGT SHAP
TOTAL NET WEIGHT

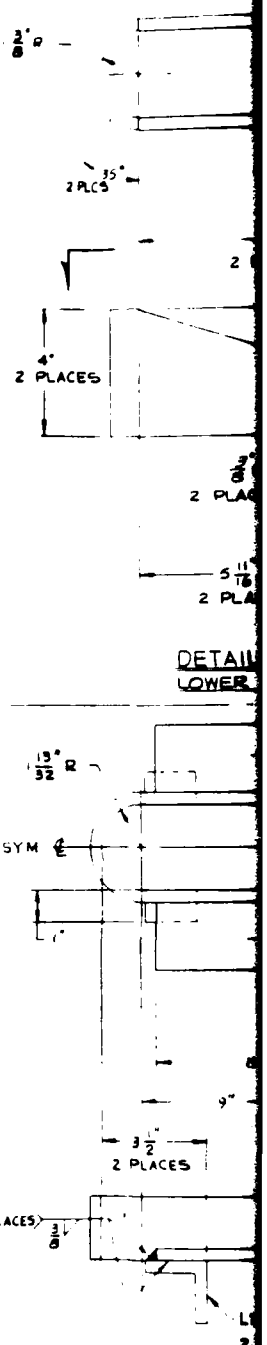
NO	MOD	D-001-A009 SHEET ASSEMBLY ALTERATION
		DATE
		LOS ANGELES
		NEWPORT BEACH
		HOUSTON
		PURCHASING
		CONSTRUCTION
		MANUFACTURING
		USED ON
		MFR

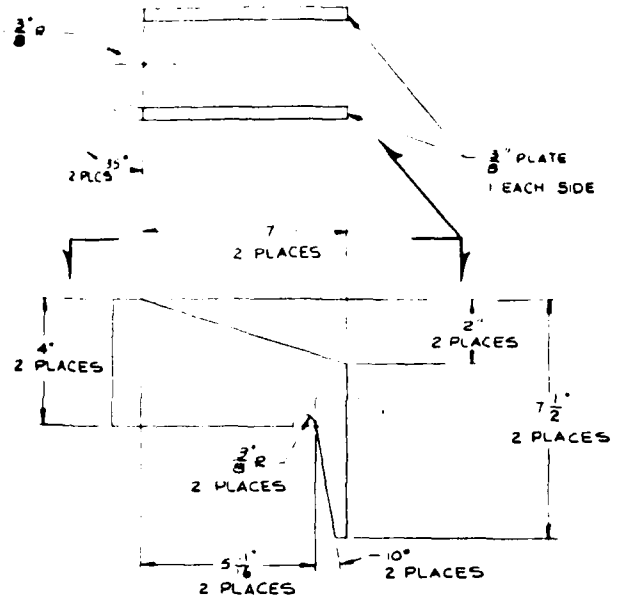




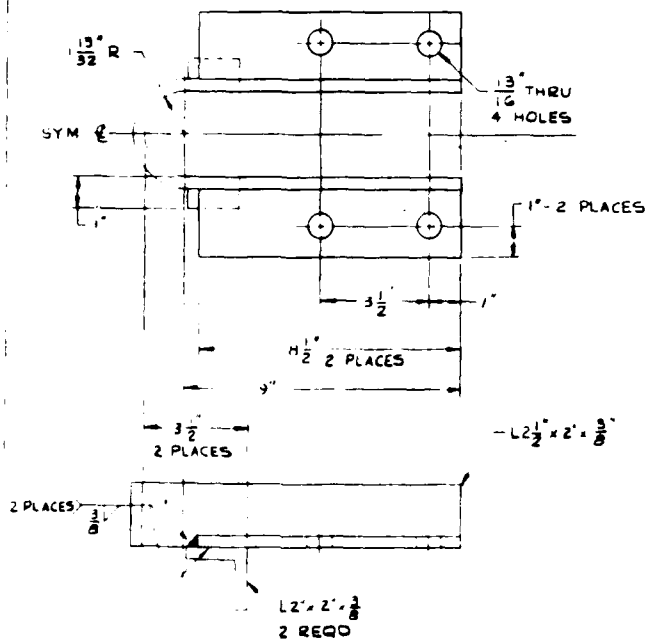
ELEVATION 6-A
WELDMENT







DETAIL 3-C
LOWER SHOE



DETAIL 3-B
UPPER SHOE

LIST OF MATERIALS				
	ITEM	QTY		
	1	2	BOLT, 5/8"-10UNC-1A x 3" LONG, HOT DIP GALV	
	2	2	NUT, 5/8"-10UNC-1B HOT DIP GALVANIZED	

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL PLATES & SHAPES TO BE PER ASTM A-36.
2. ALL WELDING TO BE IN ACCORDANCE WITH AWS PROCEDURES.
3. BREAK ALL SHARP EDGES & REMOVE ALL BURRS.

0	11 MAR 91	RELEASE FOR CONSTRUCTION	006	

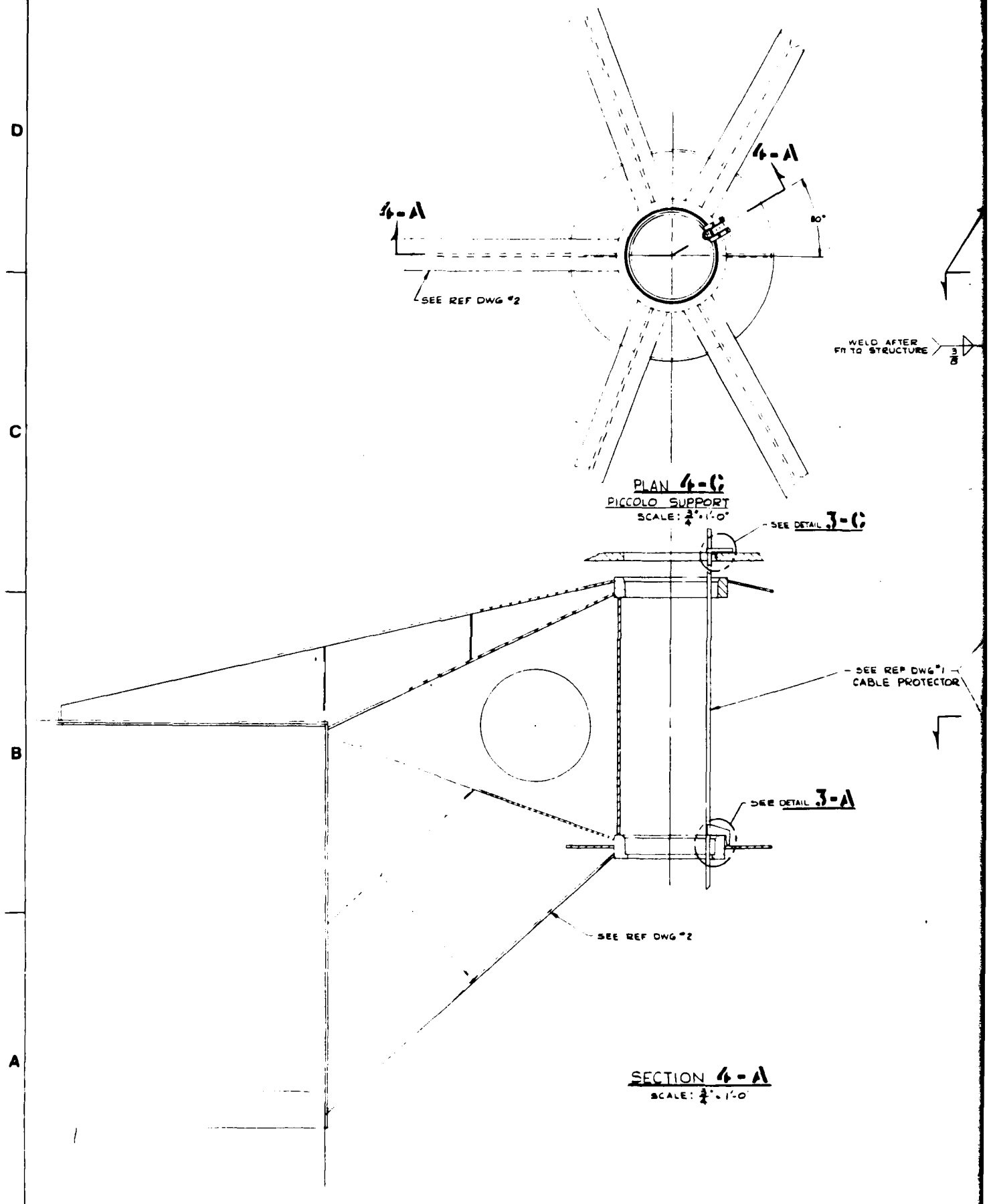
GLOBAL MARINE DEVELOPMENT INC.

[redacted]

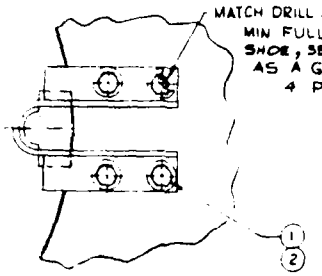
MARINE SEISMIC SYSTEM (MSS)
EM CABLE PROTECTOR AND DETAILS & ASSEMBLY

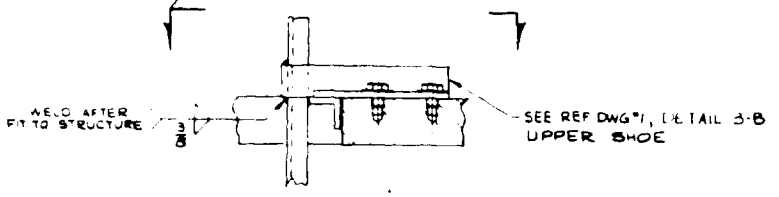
			HALF SIZE		
			00006-323000	E-001-A013	0

E-001-A014

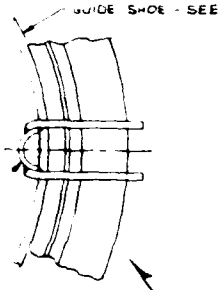

4-A
4-A
80°
SEE REF DWG #2
WELD AFTER FIT TO STRUCTURE
3/8
PLAN 4-C
PICCOLO SUPPORT
SCALE: 3/4" = 1'-0"
SEE DETAIL 3-C
SEE REF DWG #1
CABLE PROTECTOR
SEE DETAIL 3-A
SEE REF DWG #2
SECTION 4-A
SCALE: 3/4" = 1'-0"

LIST OF MATERIALS				
	ITEM	QTY	DESCRIPTION	
	1	4	HEX HD BOLT ¾"-10UNC-1A x 1" LONG - HOT DIP GALV	
	2	4	WASHER, FLAT, ¾" HOT DIP GALVANIZED	



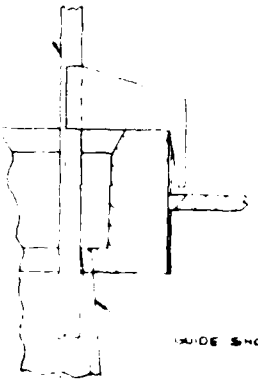


DETAIL 3-C
SCALE : 3" = 1'-0



SEE DETAIL 3-C

SEE REF DWG #1 - CABLE PROTECTOR



SEE DETAIL 3-A

DETAIL 3-A
SCALE : 3" = 1'-0

REFERENCE DRAWINGS

1.	E-001-A013	EM CABLE PROTECTOR AND DETAILS AND ASST
2.	E-377-5040	GLOMAR XI SUPPORT - 80FT PICCOLO AND GUIDE SHOE
3.	E-377-5004	GLOMAR XI GUIDE SHOE ARRANGEMENT & DETAILS

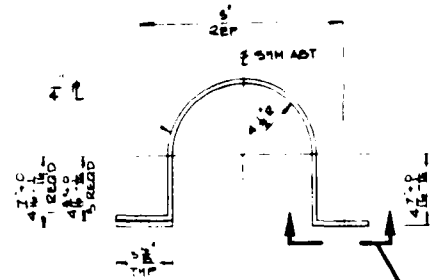
REV	DESCRIPTION	DATE
0	RELEASE FOR CONSTRUCTION	006-1 329000 A1

GLOBAL MARINE DEVELOPMENT INC.

[redacted]

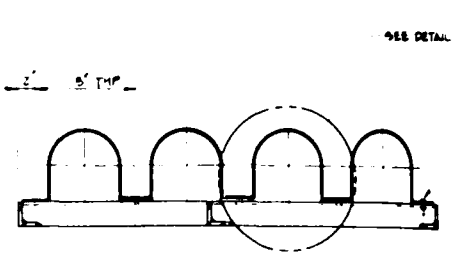
MARINE SEISMIC SYSTEM (MSS)
EM CABLE PROTECTOR
INSTALLATION ARRANGEMENT

SCALE	NOTED		
JOB NO.	10006-329000	DRG NO.	E-001-A014
SHT	1	REV	0



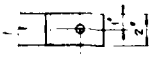
DETAIL 6-D

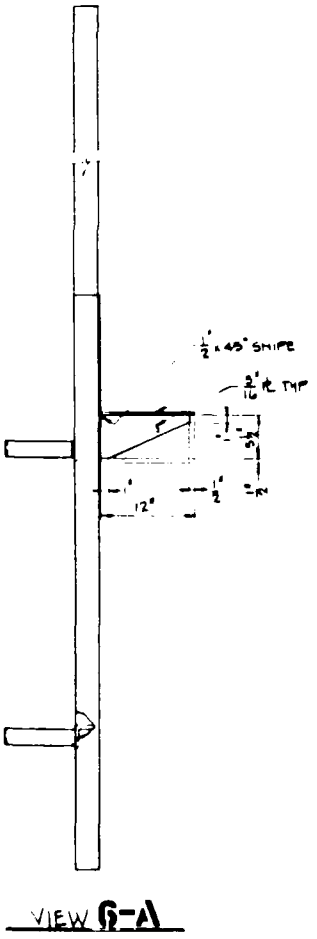
SCALE: 3"=1'-0"



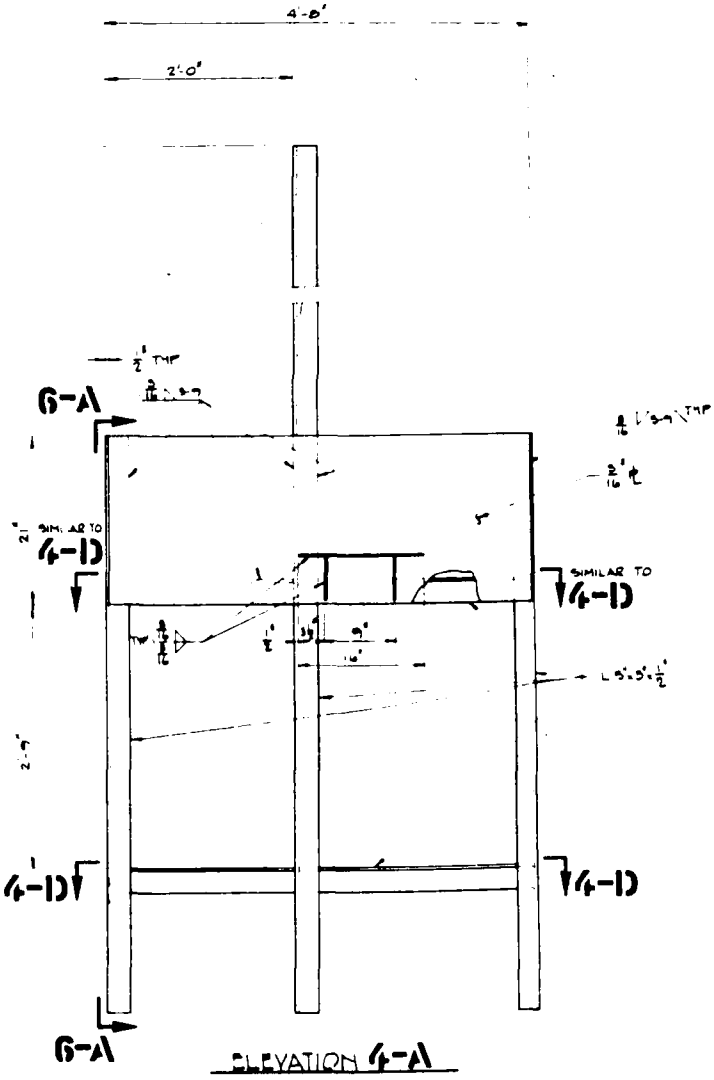
SECTION 4-D

2 REQUIRED



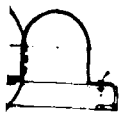


VIEW 6-A



ELEVATION 4-A

SEE DETAIL 6-1



LIST OF MATERIALS				
	1	10	1/2-13 UNC 2A x 1 3/4 LG HEX BOLT	
	2	10	1/2" PLAIN WASHER	
	3	10	1/2" LOCK WASHER	
	4	10	1/2-13 UNC 2B HEX NUT	

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL MATERIAL TO BE ASTM A-36
2. BREAK ALL EDGES & REMOVE ALL BURRS.
3. ALL WELDS TO BE 3/16" CONTINUOUS FILLET TYPE
4. FOR DECK LOCATION ON GLOMAR CHALLENGER SEE REF. DWG #1

REFERENCE DRAWINGS:

1. E-001 A012 MARINE SEISMIC SYSTEM (MSS) GLOMAR CHALLENGER INSTALLATION ARRANGEMENT

SIMILAR TO 4-1

SIMILAR TO 4-1

E-001 A020

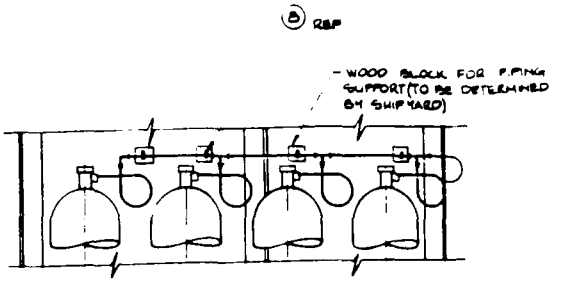
0	11 SEP 74	RELEASE FOR CONSTRUCTION	306

GLOBAL MARINE DEVELOPMENT INC.

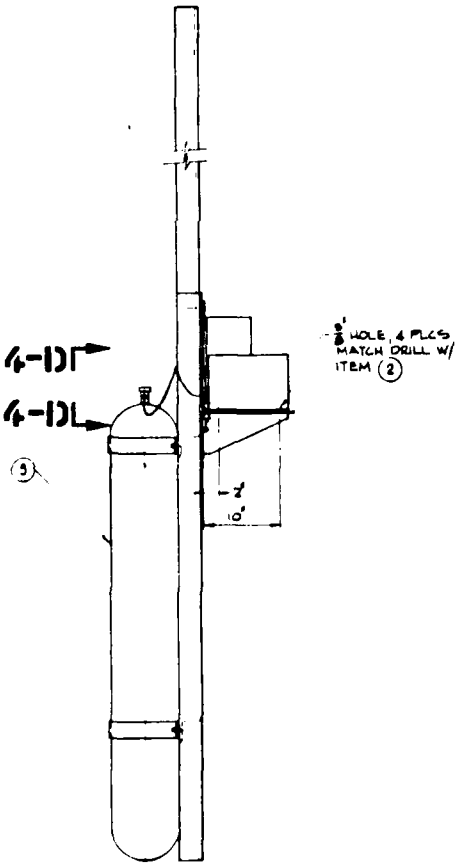
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MARINE SEISMIC SYSTEM (MSS)
HEAVE COMPENSATOR CONTROL BOARD
DETAILS AND ASSEMBLY

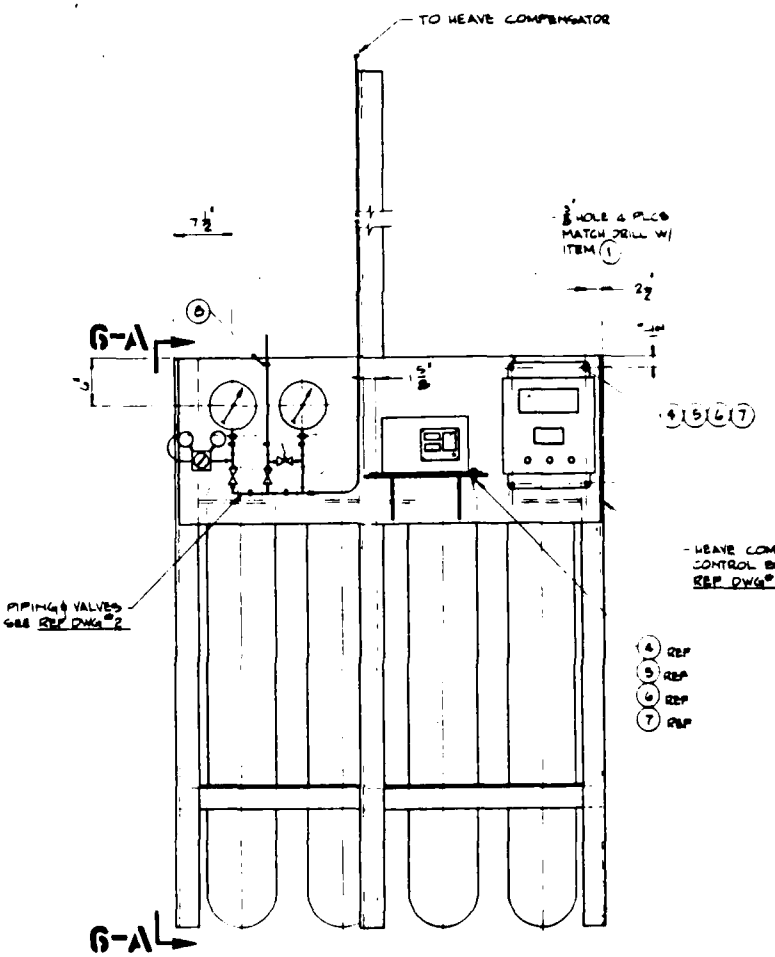
DR. H. WAGNER	11 SEP 74	1"=1'-0" & NOTED	006 329000	E-001-A018	0



VIEW 4-D



VIEW 6-A



ELEVATION 4-A

LIST OF MATERIALS				
	ITEM	QTY	DESCRIPTION	MATERIAL OR DWG. NO.
X	1	1	LINE TENSION MONITOR	MARTIN DECKER
X	2	1	LINE SPEED & LENGTH MONITOR	MARTIN DECKER
X	3	4	NITROGEN BOTTLE	
	4	8	5/16-18 UNC 2A x 1 1/2" LG HEX BOLT	
	5	8	5/16" PLAIN WASHER	
	6	8	5/16" LOCK WASHER	
	7	8	5/16-18 UNC 2B HEX NUT	
	8	10	1/2" PIPE SUPPORT CLAMP	

WOOD BLOCK FOR PIPING SUPPORT (TO BE DETERMINED BY SHIPYARD)

COMPENSATOR

3/8" HOLE & PLUG MATCH DRILL W/ ITEM (1)

2 1/2"

(5) (6) (7)

HEAVE COMPENSATOR CONTROL BOARD - SEE REF DWG # 1

(4) REF
(5) REF
(6) REF
(7) REF

REFERENCE DRAWINGS:

1. E-001-A010 MARINE SEISMIC SYSTEM (MSS) HEAVE COMPENSATOR CONTROL BOARD - DETAILS & ASSEMBLY
2. E-001-P001 MARINE SEISMIC SYSTEM (MSS) HEAVE COMPENSATOR PIPING DIAGRAM (SUPPLIED BY OTHER)

REVISIONS			
1	9 JAN 84	CHANGED NEXT ASSY WAS E 001 A012	DGG 22500
0	11 JAN 84	RELEASE FOR CONSTRUCTION	DGG 929000

E-001 A020

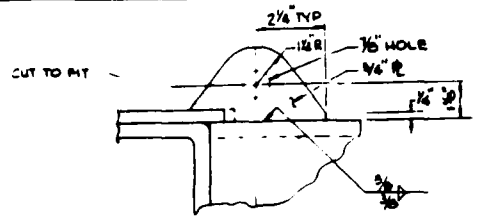
GLOBAL MARINE DEVELOPMENT INC.
Newport Beach, CA

[redacted]

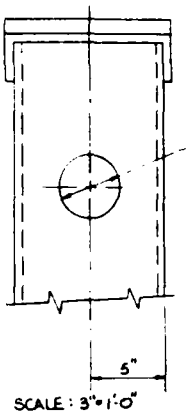
MARINE SEISMIC SYSTEM (MSS)
INSTRUMENTATION & CONTROLS
INSTALLATION

DRN M VANLANDER	11-29-83	SCALE 1"=1'-0"		
DES & ENGINEER	11-29-83			
APPROVED		DGG 929000	SIZE E	E-001-A020 REV 1

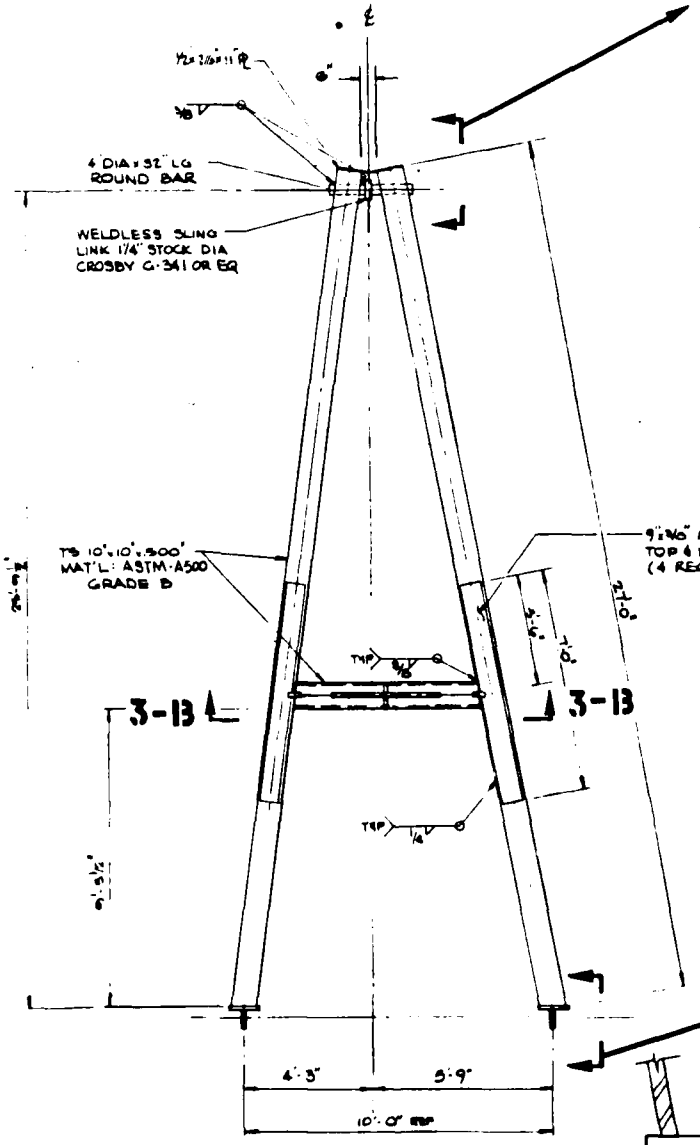
1 2 3



DETAIL **6-D**
SCALE: HALF SIZE
2 REQ'D

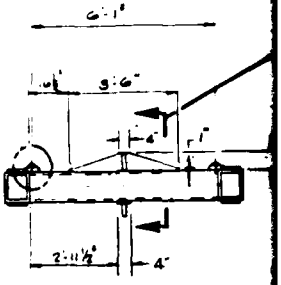


SCALE: 3"=1'-0"

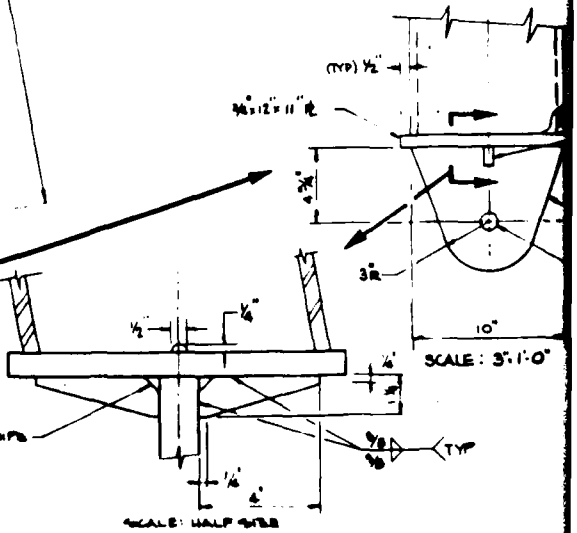


PLAN **5-A**
SCALE: ½"=1'-0"

SEE DETAIL **6-D**



SECTION **3-13**
SCALE: ½"=1'-0"

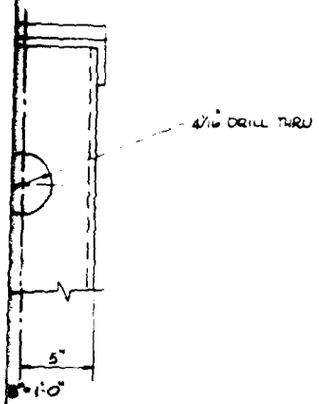


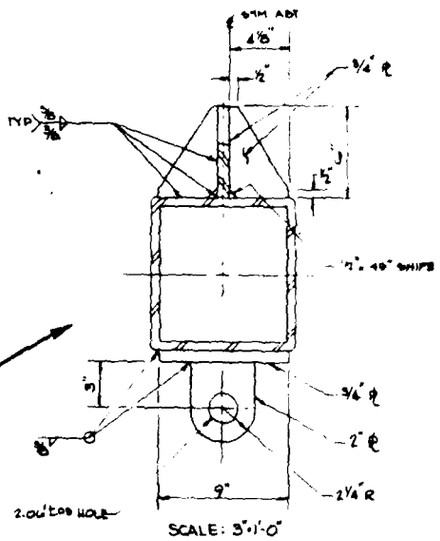
SCALE: 3"=1'-0"

SCALE: HALF SIZE

LIST OF MATERIALS

ITEM	QTY	DWG	DESCRIPTION	STOCK NO.

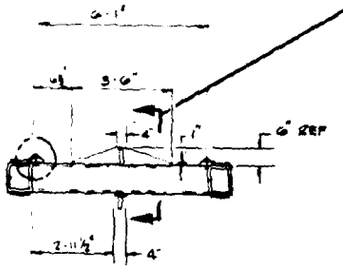




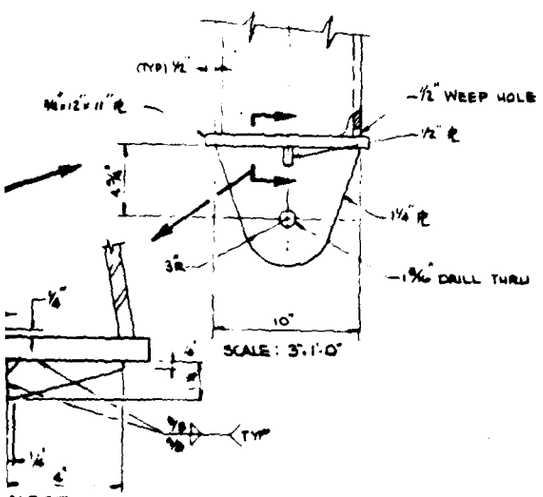
GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL MATERIAL TO BE ASTM A-36.
2. BREAK ALL EDGES & REMOVE ALL BURRS.
3. PAINT IN ACCORDANCE WITH GMD SPEC. 001-002.
4. ALL WELDING TO BE IN ACCORDANCE WITH AWS PROCEDURES.

6-1)



SECTION 3-13
SCALE: 1 1/2" = 1'-0"



REV	DATE	BY	DESCRIPTION	CUST. NO.
0	7/10/84	MM	RELEASE FOR CONSTRUCTION	006 375004
A	7/2/84	MM	PRELIMINARY RELEASE	006 375000

GLOBAL MARINE DEVELOPMENT INC.

[redacted]

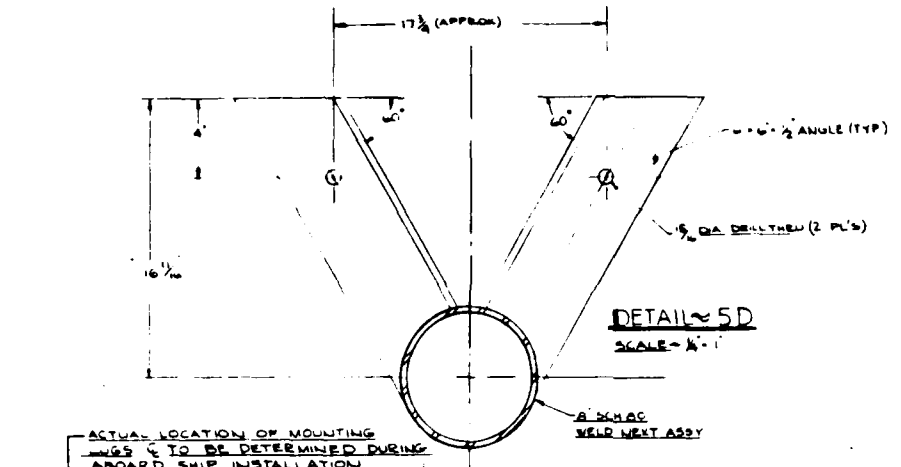
MARINE SEISMIC SYSTEM (MSS)
A-FRAME
DETAILS & ASSEMBLY

DRAWN	DATE	APPROVED
ADT	12 APR 84	AS NOTED

CUST. NO. 006 375000

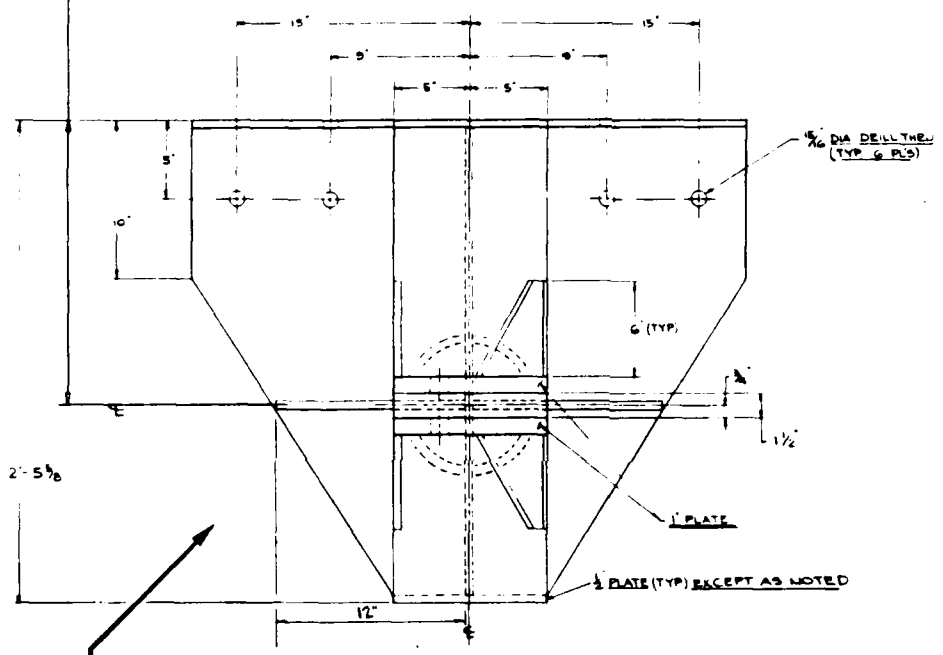
E 001 A022 0

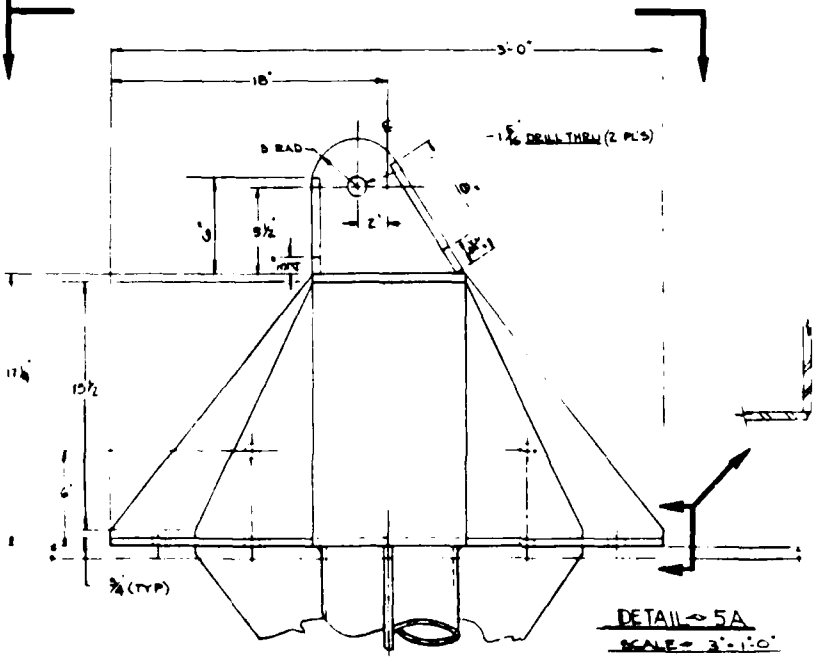
E 001 A016



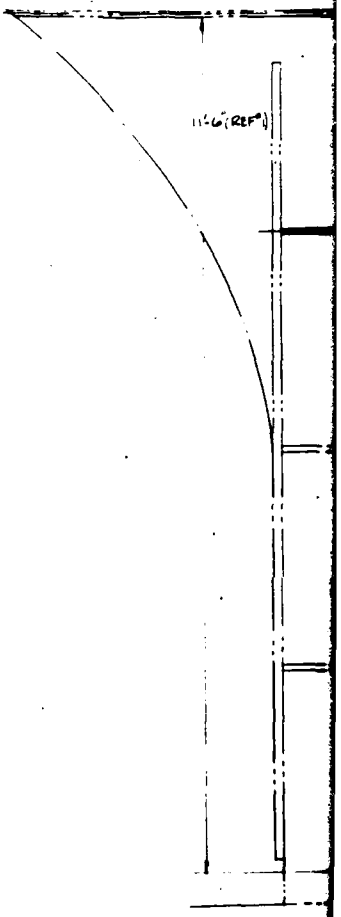
DETAIL ~ 5D
SCALE ~ 1/4" = 1"

ACTUAL LOCATION OF MOUNTING LUGS ℄ TO BE DETERMINED DURING ABOARD SHIP INSTALLATION



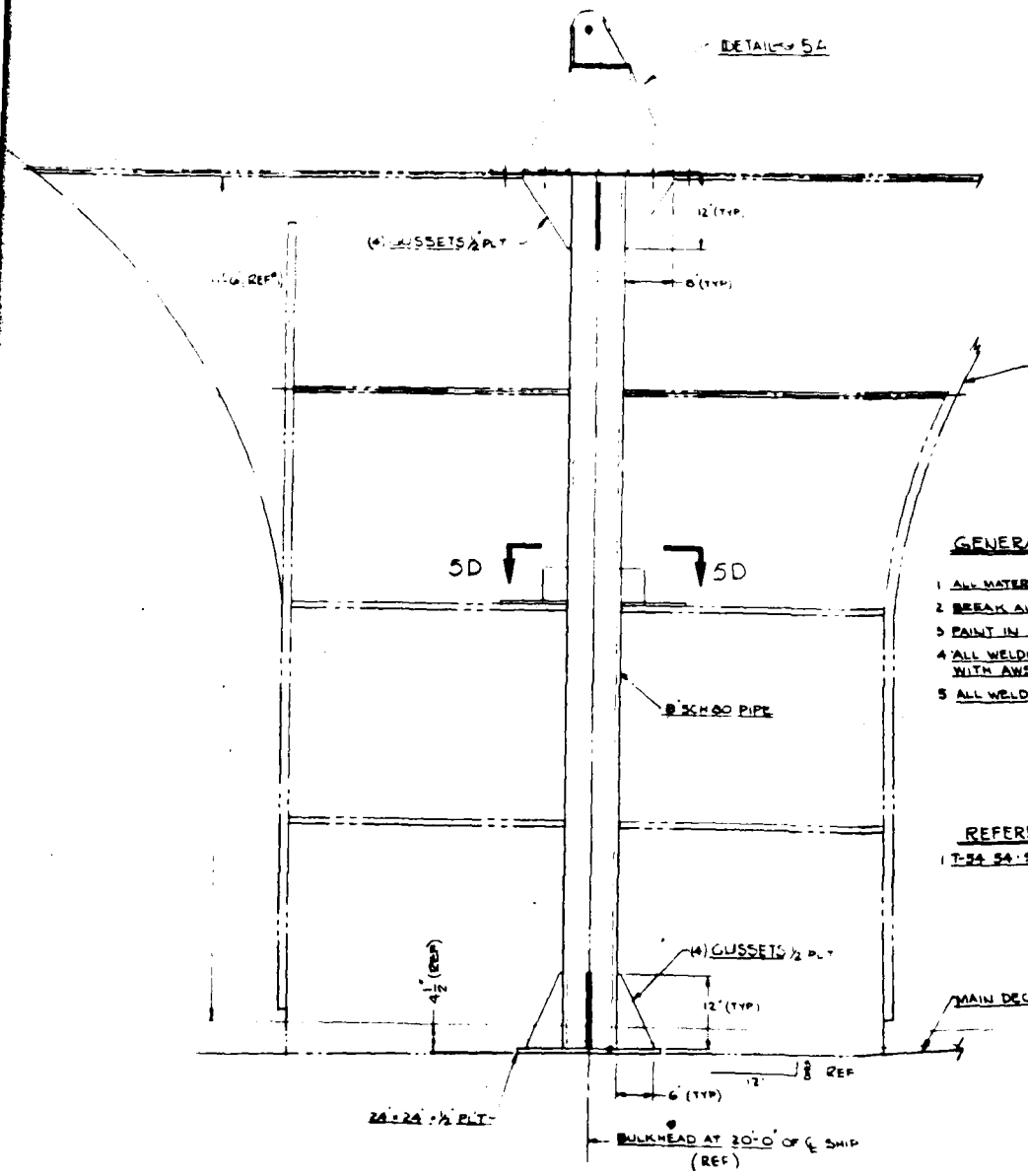


DETAIL ~ 5A
SCALE ~ 3" = 1'-0"



LIST OF MATERIALS

ITEM	NO.	QTY	DESCRIPTION	MATERIAL OR DWG. NO.



GENERAL NOTES (UNLESS OTHERWISE NOTED)

1. ALL MATERIAL TO BE ASTM A-36
2. BREAK ALL EDGES & REMOVE ALL BURRS
3. PAINT IN ACCORDANCE WITH GMD1 SPEC 001-002
4. ALL WELDING TO BE IN ACCORDANCE WITH AWS PROCEDURES
5. ALL WELDS TO BE ⅜" CONTINUOUS FILET

REFERENCE DRAWING

1	T-54-54-516	DERRICK SUB BASE DETAILS

ELEVATION "C" (LOOKING FWD - PORT SIDE)
SCALE: NONE

NO.	BY	DATE	REVISION
0			RELEASE FOR CONSTRUCTION
A			PRELIMINARY RELEASE

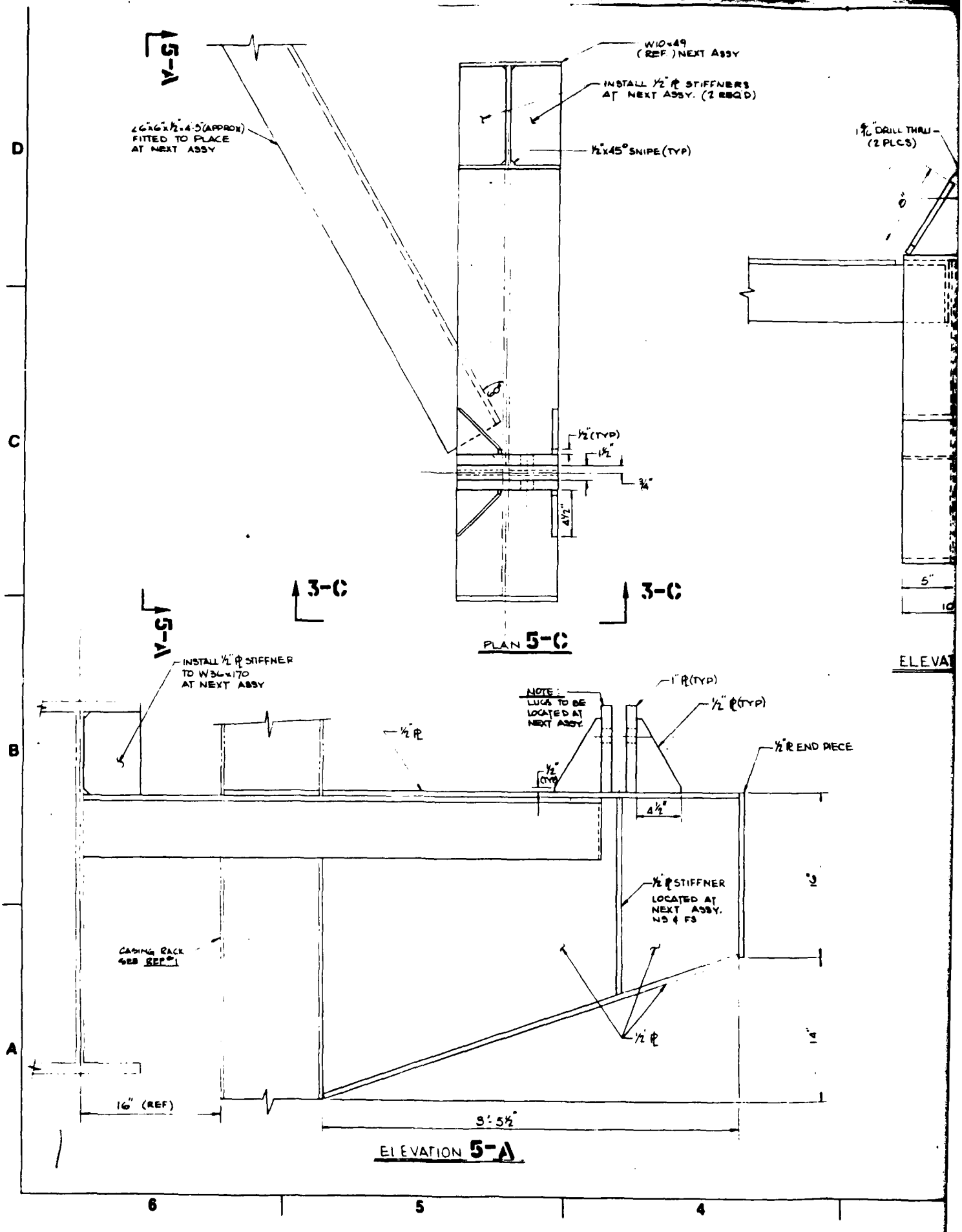
EDDI A028

GLOBAL MARINE DEVELOPMENT INC.

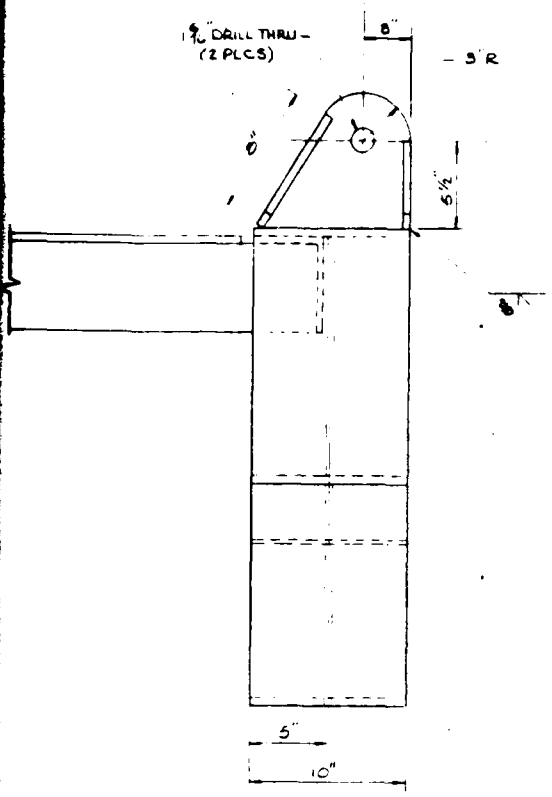
[redacted]

MARINE SEISMIC SYSTEM (MMS)
A FRAME SUPPORT TO SUB BASE
DETAILS AND ASSEMBLY

DRN ERRINGTON	2-6-90	SCALE NOTED	
DES		DWG NO 006-32300C	REV E-001-A023
ENG			SHT 1 OF 1
APP			


5-A
W10x49
(REF.) NEXT ASSY
INSTALL ½" PL STIFFNERS
AT NEXT ASSY. (2 REQ'D)
1½"x45° SNIPE (TYP)
L6"x6"x½"x4'-5" (APPROX)
FITTED TO PLACE
AT NEXT ASSY
1 9/16" DRILL THRU
(2 PLCS)
½" (TYP)
1½"
¾"
4½"
3-C
3-C
PLAN 5-C
5-A
INSTALL ½" PL STIFFNER
TO W36x170
AT NEXT ASSY
½" PL
NOTE
LUGS TO BE
LOCATED AT
NEXT ASSY.
1" PL (TYP)
½" PL (TYP)
½" PL END PIECE
½"
(TYP)
4½"
½" PL STIFFNER
LOCATED AT
NEXT ASSY.
NO 4 FS
CASING RACK
SEE REF 1
½" PL
16" (REF)
9'-5½"
ELEVATION 5-A
D
C
B
A
6
5
4

LIST OF MATERIALS



ELEVATION 3-C

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL MATERIAL TO BE ASTM A-36.
2. BREAK ALL EDGES & REMOVE ALL BURRS.
3. PAINT IN ACCORDANCE WITH GMDI SPEC. 001-002
4. ALL WELDING TO BE IN ACCORDANCE WITH AWS PROCEDURES.
5. ALL WELDS TO BE 3/16" CONTINUOUS FILLET.

REFERENCE DRAWINGS:

1 T-5454-515 CASING RACK LOCATION & DETAILS

(TYP)

1/2" R END PIECE

REV	DATE	BY	DESCRIPTION	APP'D
0	7-88	NN	RELEASE FOR CONSTRUCTION	006 373000
A	12-5-90	NOT	PRELIMINARY RELEASE	006 323000

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[redacted]

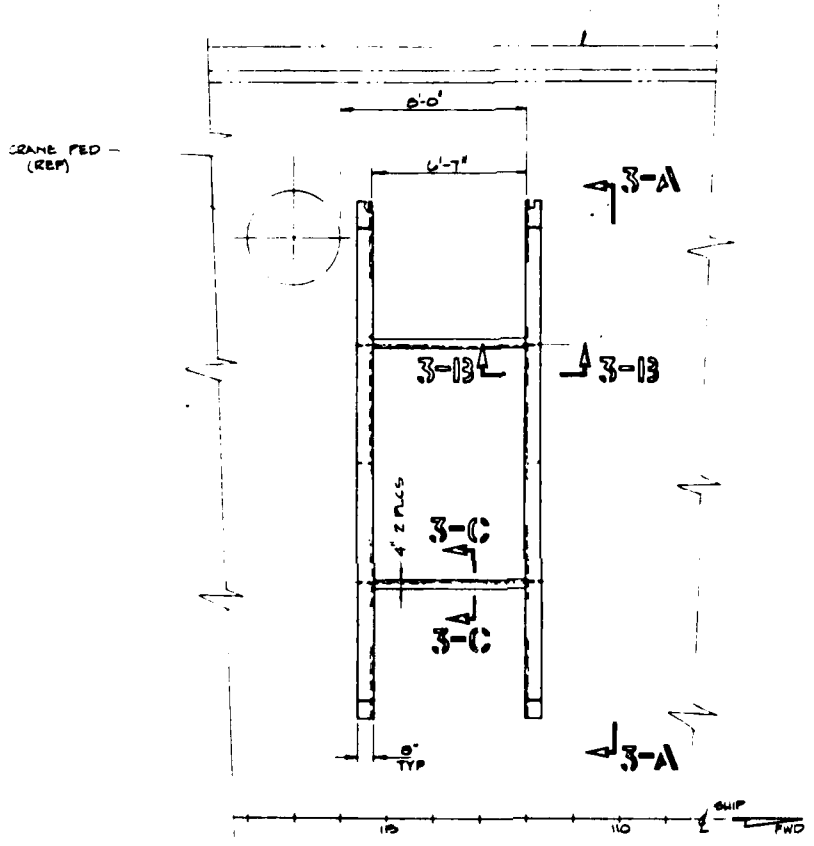
MARINE SEISMIC SYSTEM (MSS)
A-FRAME SUPPORT TO CASING RACK DETAILS

DR AOT	11-7-88	3"=1'-0"	
CH			
APP'D		006 323000	E-001-A014

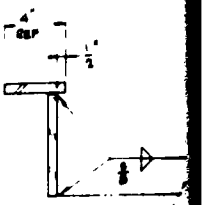
E-001 A018

3 2 1

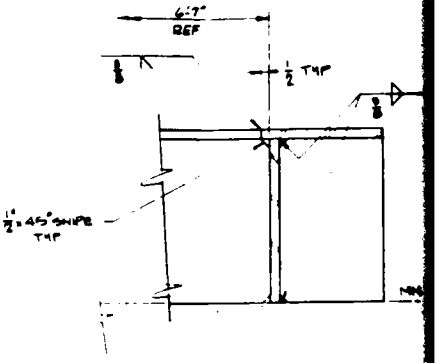
GLOMAR CHALLENGER
SEE REF DWGS 1 & 2



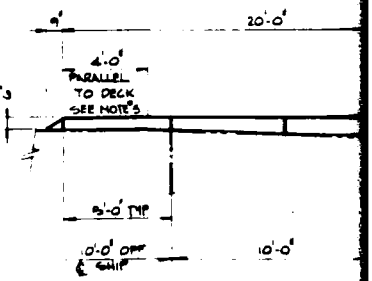
PLAN VIEW 3-A
WINCH FOUNDATION PORT SIDE AT MAIN DECK
SCALE: 3/8"=1'-0"



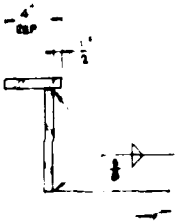
SECTION 3-C
SCALE: 3"=1'-0"



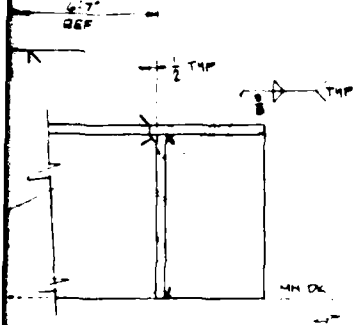
SECTION 3-13
SCALE 3"=1'-0"



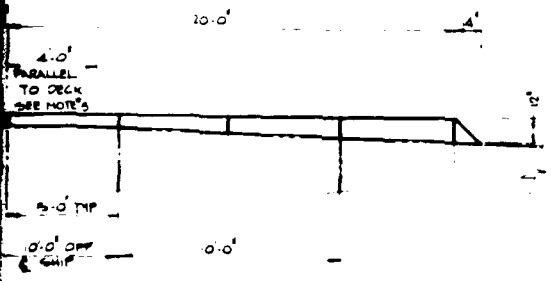
SECTION 3-
PORT SIDE FRAME 1
SCALE 3/8"=1



SECTION 3-C
SCALE 3"=1'-0"



SECTION 3-B
SCALE 3"=1'-0"



SECTION 3-A (3)
PORT SIDE FRAME 110 LOOKING AFT
SCALE 3/8"=1'-0"

LIST OF MATERIALS

MARK	PCS	QTY	DESCRIPTION	MATERIAL SPEC & GRADE

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. ALL MATERIAL TO BE A6TM A-36.
2. FRAME SPACING IS 2'-0" IN AREA CONCERNED.
3. DECK HAS CAMBER BUT NO SHEER.
4. ALL MATERIAL TO BE 5/8" PLATE.

REFERENCE DRAWINGS:

1. D-8TT-A003 GLOMAR CHALLENGER ARRANGEMENT-MAIN DECK & BELOW
2. T-64-54-H126 DECK PLATING & FRAMING SECTIONS & DETAILS

NO.	DATE	BY	DESCRIPTION	JOB NUMBER
0	1-10-80	RWJ	RELEASE FOR CONSTRUCTION	006 925000
A	12-5-80	RWJ	PRELIMINARY RELEASE	006 925000

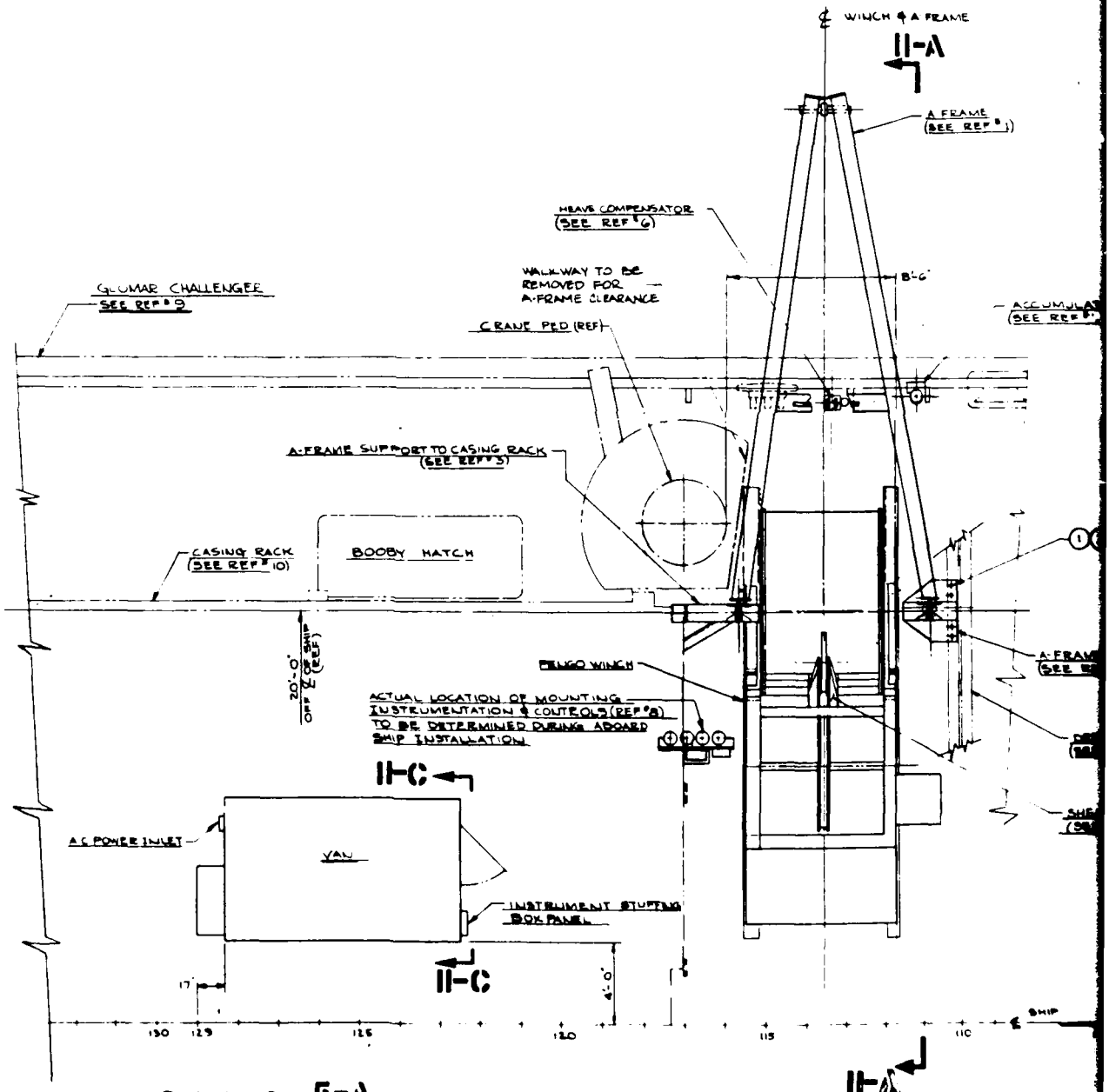
E 001 A028

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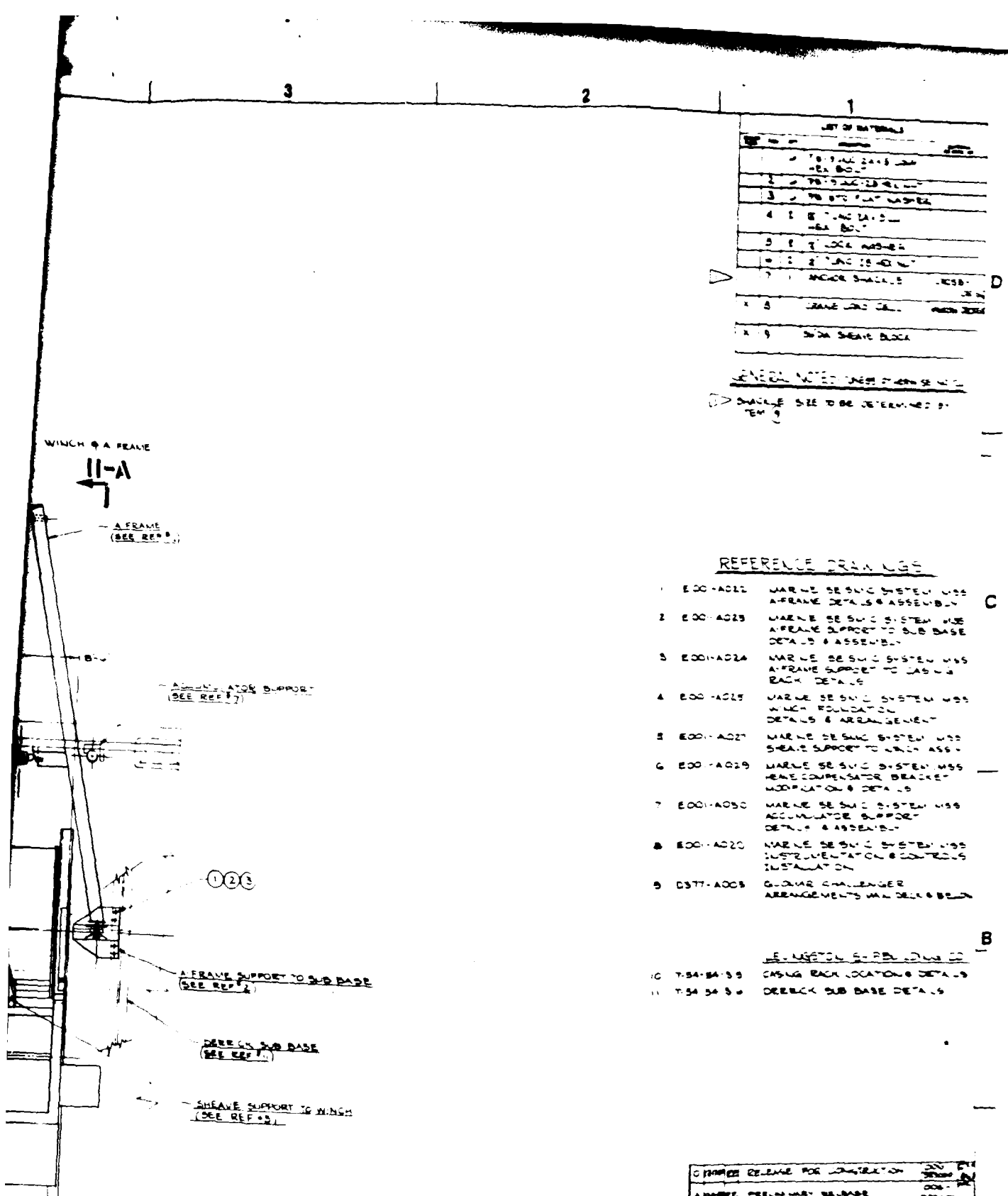
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MARINE SEISMIC SYSTEM (MSS)
WINCH FOUNDATION
DETAILS AND ARRANGEMENT

DRAWN	12-5-80	SCALE	AS NOTED
CHECKED			
APPROVED	12-5-80	JOB NUMBER	006 925000
DRAWING NUMBER			E-001-A025
SHEET			1 OF 1
REV			0



PLAN VIEW 5-A1



7	1	ANCHOR SHACKLE
8	1	CRANE LOAD CELL
9	1	3x3A SHEAVE BLOCK

GENERAL NOTES UNLESS OTHERWISE NOTED

1. SHACKLE SIZE TO BE DETERMINED BY ITEM 9

REFERENCE DRAWINGS

1	E00-A022	MARINE SEISMIC SYSTEM MISC A-FRAME DETAILS & ASSEMBLY
2	E00-A023	MARINE SEISMIC SYSTEM MISC A-FRAME SUPPORT TO SUB BASE DETAILS & ASSEMBLY
3	E00-A024	MARINE SEISMIC SYSTEM MISC A-FRAME SUPPORT TO GASUN RACK DETAILS
4	E00-A025	MARINE SEISMIC SYSTEM MISC WINCH FOUNDATION DETAILS & ARRANGEMENT
5	E00-A027	MARINE SEISMIC SYSTEM MISC SHEAVE SUPPORT TO WINCH ASSY
6	E00-A029	MARINE SEISMIC SYSTEM MISC HEAVE COMPENSATOR BRACKET MODIFICATION & DETAILS
7	E00-A030	MARINE SEISMIC SYSTEM MISC ACCUMULATOR SUPPORT DETAILS & ASSEMBLY
8	E00-A020	MARINE SEISMIC SYSTEM MISC INSTRUMENTATION & CONTROLS INSTALLATION
9	D377-A005	GLOMAR CHALLENGER ARRANGEMENTS MAIN DECK & BELOW

EXISTING SUPPLEMENTAL DRAWINGS

10	T-54-84-S-5	CASING RACK LOCATION & DETAILS
11	T-54-54-S-6	DERRICK SUB BASE DETAILS

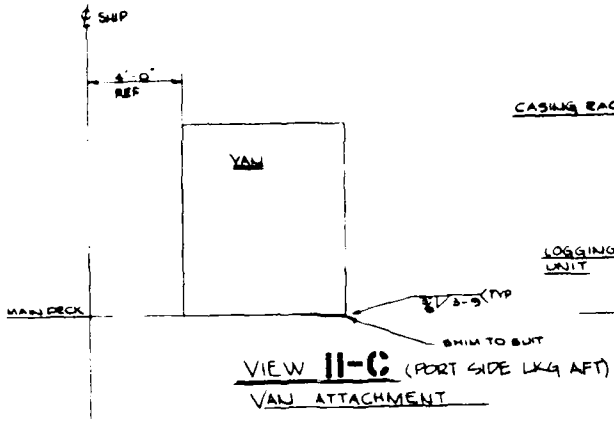
C	RELEASE FOR CONSTRUCTION		
B	PRELIMINARY RELEASE		
A	ISSUED FOR BID		

GLOBAL MARINE DEVELOPMENT INC

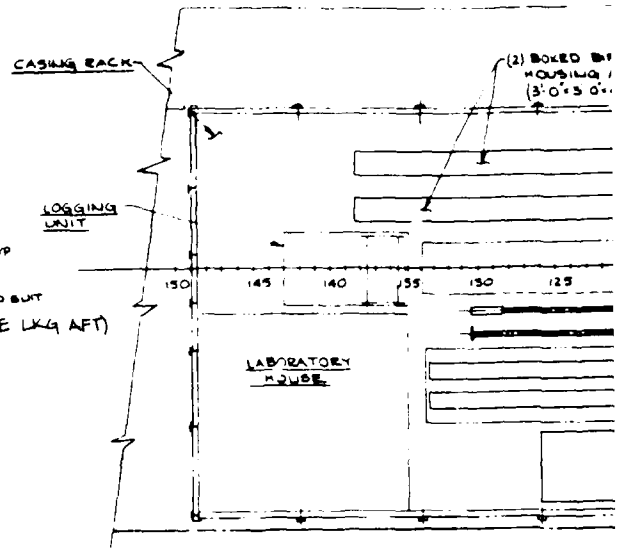
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MARINE SEISMIC SYSTEM MISC
GLOMAR CHALLENGER EQUIPMENT INSTALLATION ARRANGEMENT

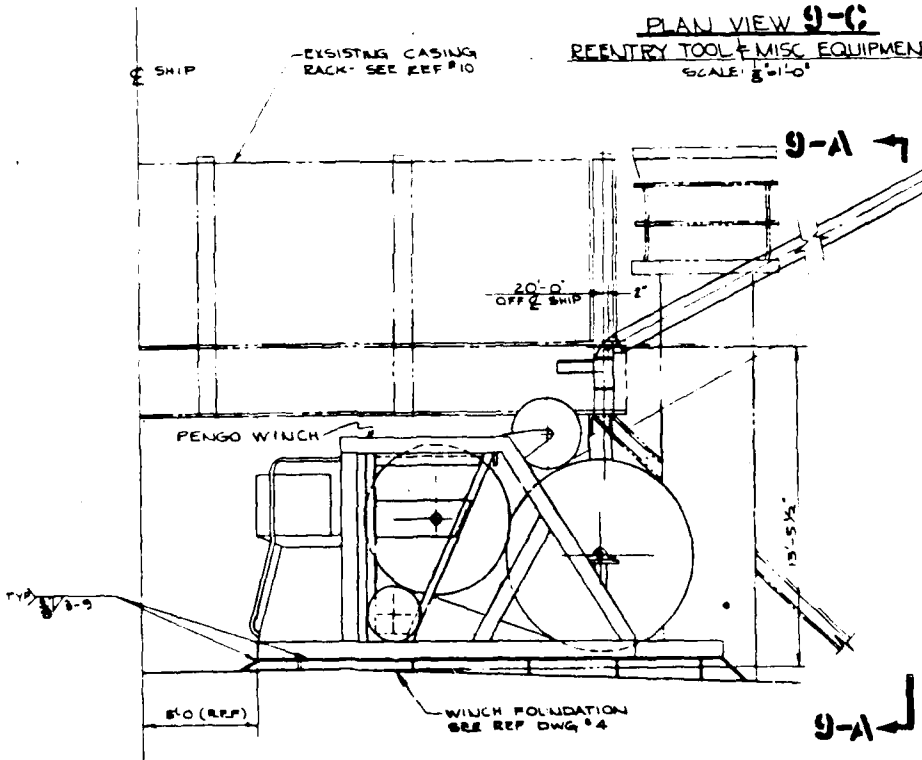
E-00



VIEW 11-C (PORT SIDE LKG AFT)
VAN ATTACHMENT

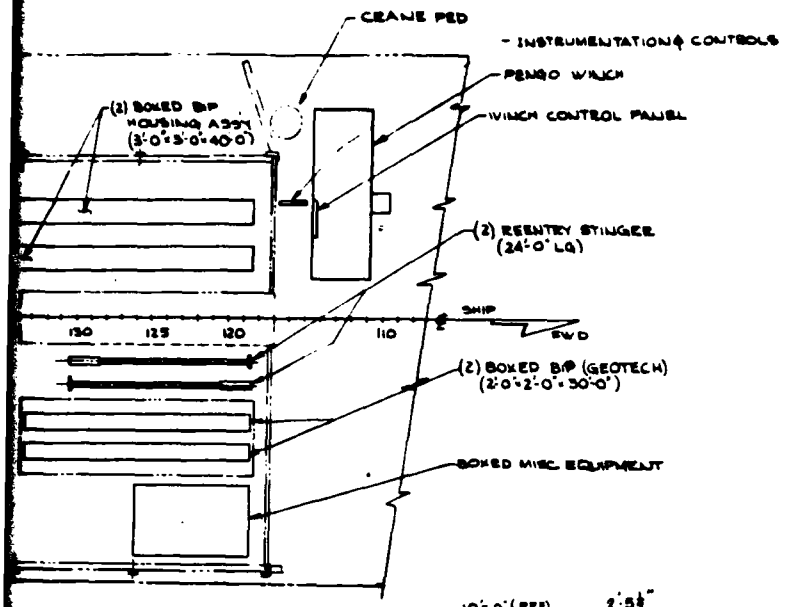


PLAN VIEW 9-C
REENTRY TOOL & MISC. EQUIPMENT STORAGE
SCALE: 3/8"=1'-0"

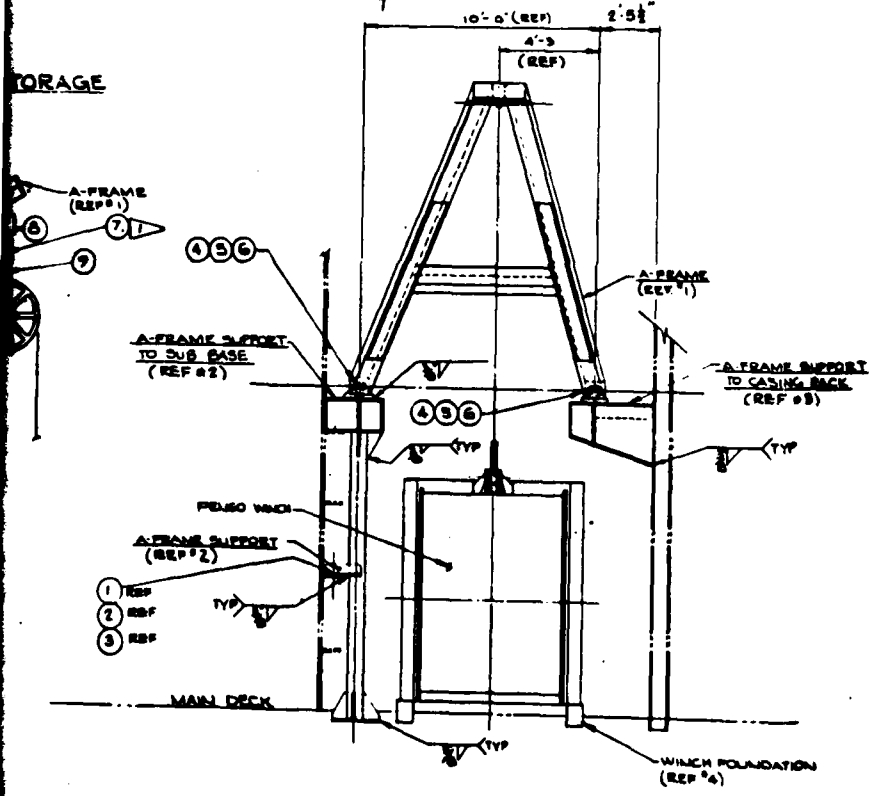


SECTION 11-A
PORT SIDE FR111 LOOKING AFT

LIST OF MATERIALS



TORAGE



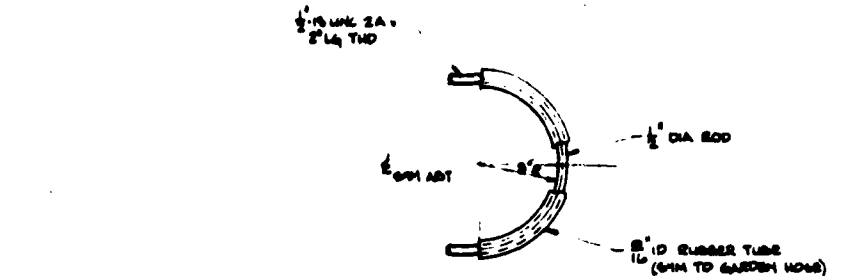
ELEVATION 9-A

PORT SIDE (LOOKING INBD)
(CRANE PED REMOVED FOR CLARITY)

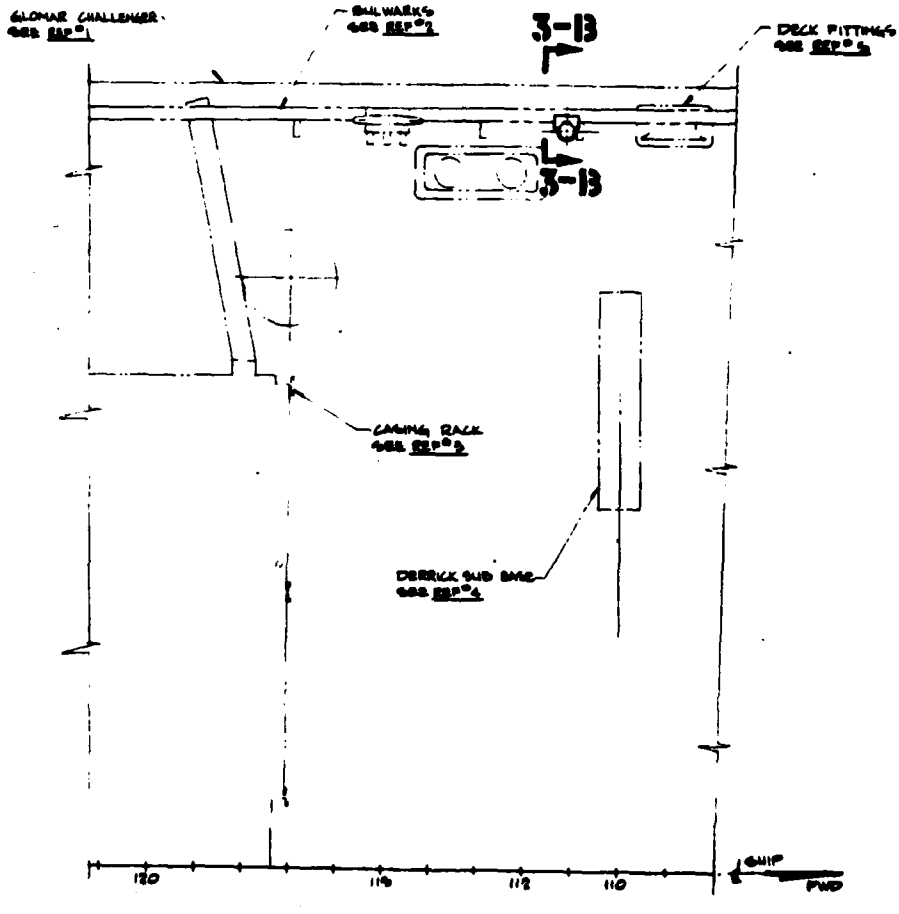
GLOBAL MARINE DEVELOPMENT INC.

MARINE SEISMIC SYSTEM (MSS)
GLOMAR CHALLENGER
INSTALLATION ARRANGEMENT

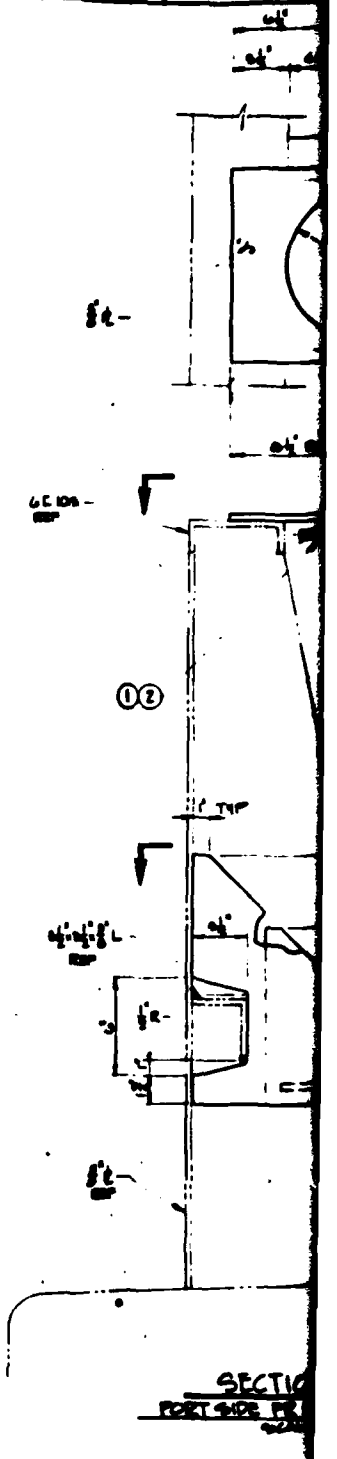
E-001 • A02B

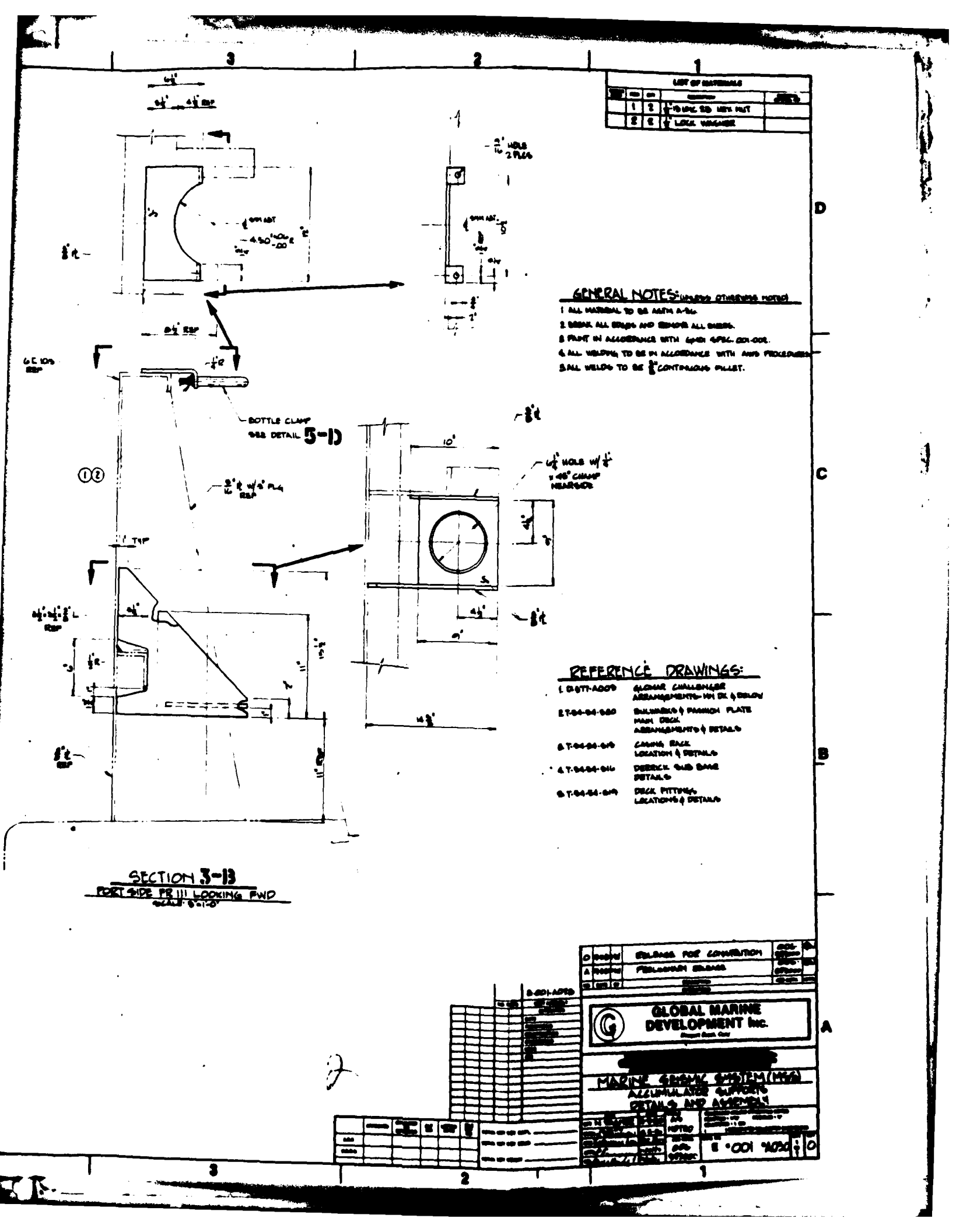


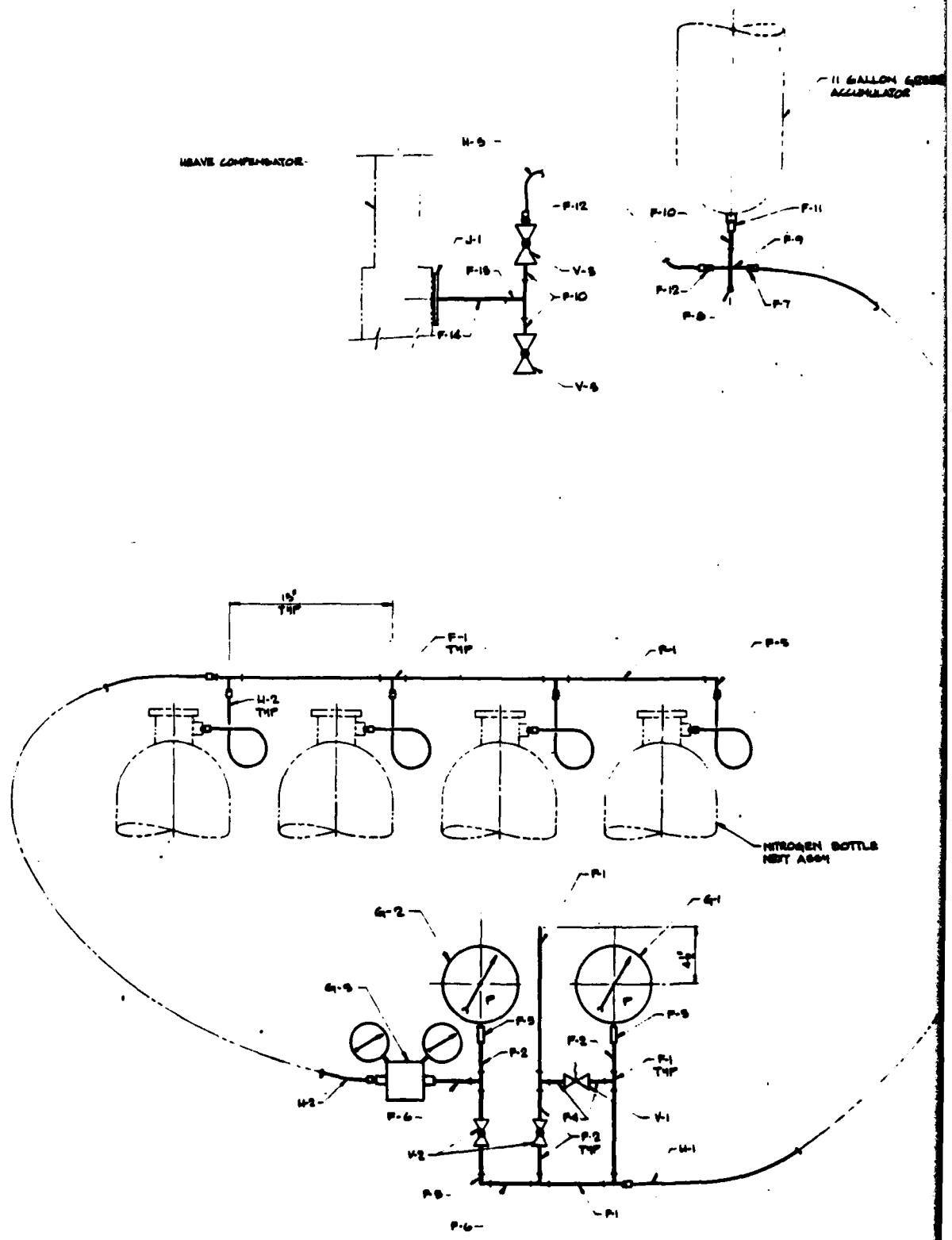
DETAIL 5-D
BOTTLE CLAMP
SCALE: 3"=1'-0"

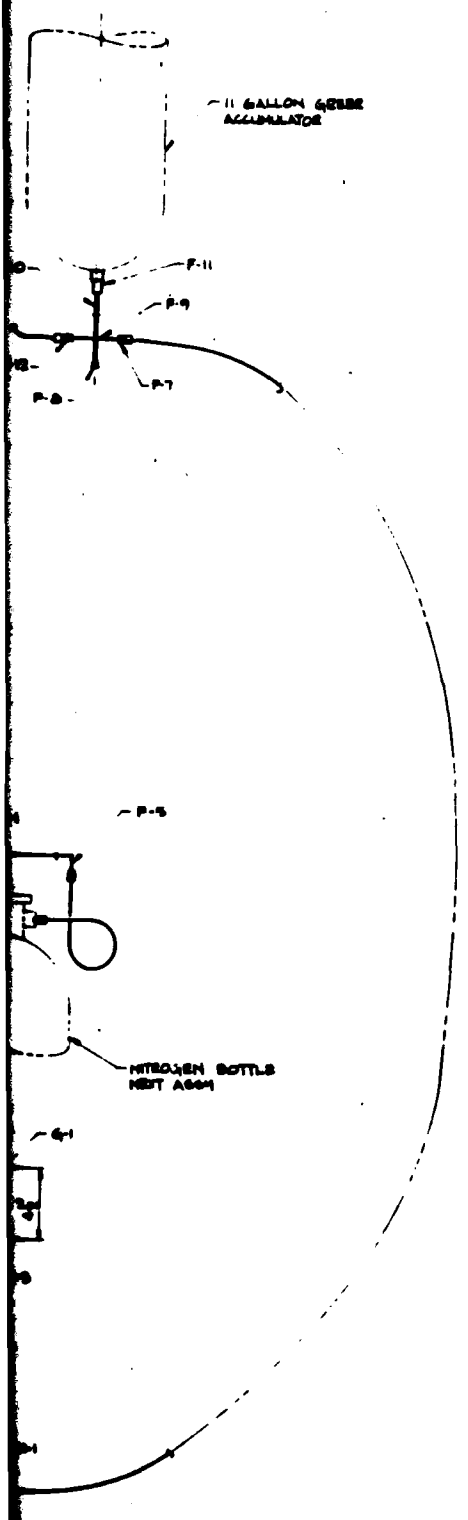


PLAN VIEW 5-A
PORT SIDE FR 109 TO FR 121
ACCUMULATOR SUPPORT LOCATION
SCALE: ⅛"=1'-0"




BOTTLE CLAMP
SEE DETAIL 5-D
SECTION 3-B
PORT SIDE FR 111 LOOKING FWD
GENERAL NOTES: (UNLESS OTHERWISE NOTED)
1 ALL MATERIAL TO BE ASTM A-36.
2 BREAK ALL SHARP AND REMOVE ALL BURRS.
3 PAINT IN ACCORDANCE WITH GMDI SPEC. 001-002.
4 ALL WELDING TO BE IN ACCORDANCE WITH AWS REQUIREMENTS.
5 ALL WELDS TO BE 1/4" CONTINUOUS FILLET.
REFERENCE DRAWINGS:
1 D-077-A005 GLOMAR CHALLENGER ARRANGEMENTS - MN DK & BELOW
2 T-04-04-080 BULWARKS & PANNOH PLATE MAIN DECK ARRANGEMENTS & DETAILS
3 T-04-04-070 CASING RACK LOCATION & DETAILS
4 T-04-04-010 DERRICK SUB BASE DETAILS
5 T-04-04-070 DECK FITTINGS LOCATIONS & DETAILS
GLOBAL MARINE DEVELOPMENT INC.
MARINE RISER SYSTEM (MRS)
ACCUMULATOR SUPPORTS
DETAILS AND ASSEMBLY
E-001 ADED


HEAVE COMPENSATOR
H-3
P-12
J-1
P-13
V-3
P-10
P-14
V-4
11 GALLON
ACCUMULATOR
P-10
P-11
P-9
P-12
P-7
P-8
15"
THP
F-1
THP
P-1
P-5
H-2
THP
NITROGEN BOTTLE
NEST ASSY
P-1
G-2
G-1
P
P
P-3
P-3
P-2
P-2
G-3
P-1
THP
H-2
P-6
P-4
V-1
H-2
P-2
THP
H-1
P-8
P-1
P-6



LIST OF MATERIALS				
	ITEM	QTY	DESCRIPTION	SPEC'S
	P-1	4	¼" THD TEE - 3000#	
	P-2	6	¼" x 3" LG THD NIPPLE SCH 80	ASTM A-53 GRADE A-STL.
	P-3	2	¼" THD CROSS - 3000#	ASTM A-105 GRADE A-STL.
	P-4	2	¼" x 2" LG THD NIPPLE SCH 80	ASTM A-53 GRADE A-STL.
	P-5	2	¼" THD 90° ELBOW 3000#	ASTM A-105 GRADE A-STL.
	P-6	2	¼" x 6" LG THD NIPPLE SCH 80	ASTM A-53 GRADE A-STL.
	P-7	1	1" x ¼" THD RED BUSHING 3000#	ASTM A-105 GRADE A-STL.
	P-8	1	1" THD PLUG - 3000#	
	P-9	1	1" THD CROSS - 3000#	
	P-10	8	1" x 2" LG THD NIPPLE SCH 80	ASTM A-53 GRADE A-STL.
	P-11	1	2" x 1" THD RED BUSHING 3000#	ASTM A-105 GRADE A-STL.
	P-12	2	1" MALE THD/MALE JIC 37° FLARE HOSE ADAPTOR SWIVEL SAE 4-11 A 16	STEEL
	P-13	1	1" THD TEE - 3000#	ASTM A-105 GRADE A-STL.
	P-14	1	1" x 6" LG THD NIPPLE SCH 80	ASTM A-53 GRADE A-STL.
	G-1	1	GAUGE - 6" DIA 0-1500 PSI	
	G-2	1	GAUGE - 6" DIA 0-3000 PSI	
	G-3	1	REGULATOR - INLET PRESS 2500 PSI OUTLET PRESS. FROM 500 PSI TO 1500 PSI ¼" NPT	
	H-1	1	¼" SWIVEL HOSE x 10 FT LG W/ MALE PIPE SWIVEL ENDS - TYPE 5105-04-40-40-040	
	H-2	9	¼" SWIVEL HOSE x 18" LG W/MALE PIPE SWIVEL ENDS TYPE 5105-04	
	H-3	1	1" SWIVEL HOSE x 10 FT LG W/ FEMALE SWIVEL ENDS - TYPE 5100-16	
	J-1	1	PIPE THREADED 2" 150# FLANGE 3000 PSI	
	P-1	3 FT	¼" SCH 80 PIPE	ASTM A-53 GRADE A-STL.
	V-1	1	¼" THD IN-LINE RELIEF VALVE SET @ 1500 PSI	STEEL
	V-2	2	¼" BALL VALVE	
	V-3	12	1" BALL VALVE	

GENERAL NOTES: (UNLESS OTHERWISE NOTED)

1. REMOVE GAUGES WHEN PRESSURE TESTING.
2. ALL PIPING TO BE TESTED AT 2500 PSI.
3. GAS RELIEF VALVE (V-1) DURING PRESSURE TESTING.

REVISIONS			
ZONE	REV	DESCRIPTION	DATE
	O	RELEASE FOR CONSTRUCTION	
	A	PRELIMINARY RELEASE	

GLOBAL MARINE DEVELOPMENT Inc.

[redacted]

MARINE SEISMIC SYSTEM (MSS)

HEAVE COMPENSATOR PIPING DIAGRAM

S-001-A01-2

2

E-001-T001 | SHT 1 | REV 0

D C B A